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GAMING AS A SERVICE
RESEARCH ASSESSMENT TOOLKIT

BY

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Abstract

The purpose of this research is to design and determine the effectiveness of using a Gaming as a Service (GaaS) Research Assessment Toolkit to facilitate and evolve GaaS research, and improve the end user experience. Previous research spanning a twelve-year period from 2006 to 2018 reveals that identified fundamental GaaS problems are being carried over into ongoing and future GaaS research. Each year new research experiments and approaches to solving ongoing GaaS issues are presented by the education and research community. The literature and this research reveal that there is a place for a unified facilitative tool, specifically a research assessment toolkit to facilitate, test, optimize and minimize common GaaS carry over issues, as GaaS evolves. This research introduces a unified, multiplatform and embedded smart application, the GaaS RATK with bundled assessment and optimization tools. The research establishes how the GaaS RATK is beneficial to GaaS and its community.

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1 CHAPTER I – INTRODUCTION

This research focuses on the design, development and evaluation of a Gaming as a Service (GaaS) Research Assessment Toolkit (RATK) that is a facilitative vehicle for developing, evolving and testing new GaaS research, while also endeavoring to optimize current and future end user GaaS experiences. In this chapter, I will explain the motivation for completing this research, describe the goals and possible contributions that this research has on offer, and explain the structure of this thesis.

1.1 Motivation

Gaming as a Service is defined as video game content being delivered from an internet or network connected server to a client using a compressed video stream, with game controls being sent from the client to the server. Graphics accelerated rendering, game logic and video encoding are performed at the server level; the client is responsible for decoding the video stream and collecting user inputs (Slivar, Skorin-kapov, & Suznjevic, 2016). Gaming as a Service (GaaS) opens up several new exciting prospects for playing video games. The identified novel features of GaaS include relief of expensive hardware investment and upgrades, platform independence, ubiquity and instant play without the requirement of installing or configuring the game (Xue, Wu, He, Hei, & Liu, 2015). The only requirement is that the chosen device is compatible, and powerful enough to run the client.

As of 2016, statistics show that 80% of all internet users own a smart device and 89% of their time is spent using apps and playing games (Chaffey, 2016). The hunger for quality gaming options and apps on mobile devices has opened up an opportunity for GaaS to provide gamers an enriched gaming experience on less-powered mobile devices. Excitement about GaaS research spanning 2006 to 2016 indicates that GaaS is the holy grail of low barrier gaming entry for mobile devices and minimal specification set top multimedia boxes. According to Ross (2009), cloud computing's killer app itself, is GaaS.

While research and development of GaaS has been promising to date, gaming is a very different beast from applications that were programmed within buffered video streaming framework and API's. GaaS has very specific responsive real-time requirements that internet streaming video does not have. Choy, Wong, Simon, & Rosenberg (2014), explains that technology for video streaming is closely related to GaaS, since it's consists of sending a video stream back to the client. They also claim that a gamer's real-time gaming low latency needs are not compatible with video streaming technology that relies on playback buffers. This holds especially true with Twitch gaming (first person shooters, action games, timed side-scrollers). According to the research done by Chuah, Yuen, & Cheung (2014), it is estimated that a gamer must be able to react within 100ms to succeed within the Twitch video game genre. First person shooters are a prime example of this. If you shoot late for any reason, your character is dead.

The Cloud based foundation of which GaaS was built on to allow mobility and freedom with minimal game optimization, is what has led to many of the problems with GaaS. GaaS uses internet and network technology to power cloud based mobility and requires network infrastructure and the thin-client[1] be finely tuned and customized to have a positive gaming experience. It requires high bandwidth with low-latency for input control and constant real-

[1] Thin-client refers to the application on the mobile device that is delivering the video game screen to the user from the GaaS Server, and providing user inputs.

time streaming of video and sound. The gamers' physical hand eye coordination, reactions and response to games, require that there be very little latency. Unfortunately, latency related to GaaS networks and the compression required for 720p and 1080p real-time gaming, often leads to the issues of video encoding and output which are related to stutter, jitter, packet loss, frame-loss, frame rate drop and complete blackout.

Stavert (2015), noted a new error phenomenon related to latency and lack of optimization within networks and clients that caused a term he coined as "total blackout". From around 2006 to the current date 2018 (A twelve year period) the same issues fundamentally still exist within the GaaS gaming realm. Although some improvements in client compression and algorithm technology have occurred, all GaaS services, public and private suffer from these known problems related to latency and lack of optimization among thin-clients and networks. Chen, Chang, & Tseng (2011), explored the problem of latency among different GaaS systems, while also acknowledging cloud latency as a problem as far back as 2006. Choy et al. (2012), explored the GaaS issue further, while also emphasizing the direct effect latency has on encoding, video output, video quality, input and response actions. Hong et al. (2015), acknowledged that problems related to latency and lack of optimization were still an issue, and tested various ways to implement adaptive technology within an open source GaaS system. Their work is very impressive and provides a solution for one particular GaaS system, but it also highlights the need for more research and development for further problem reduction methods and standards across multiple GaaS systems.

Reoccurring issues that remain a part of the GaaS development cycle and evolution are the driving factors and motivation for this research. The objective of this research is to contribute to the solution of long-term ongoing GaaS issues. The goal is to entice further research and development of GaaS, by providing a centralized entry level GaaS Research Assessment Toolkit (GaaS RATK) that identifies and diagnoses common GaaS issues for use by armchair GaaS enthusiasts, and academia. There are scattered network diagnostic toolsets that can be used to diagnose and refine GaaS services, but the proposed centralized research toolkit and GaaS assessment tools, could benefit both gamers and researchers.

1.2 Goal and Contribution

The goal and contribution of this research is to provide a unified and centralized GaaS RATK that includes an affordable and complimentary open device with a thin-client, and a series of tuning and diagnostic applications. The toolkit is the representation of the research outcome. The toolkit will help gamers and researchers optimize their GaaS experiences while discovering new areas of research and ways to test and optimize new methodologies. Stavert (2015), conducts an experiment that noted GaaS operational problems between thin-client versioning and network optimization; therefore highlighting that it is hard to determine the source of the GaaS issues among them, without optimized and centralized assessment applications. The toolkit can also provide research and development teams a consistent method to test if GaaS issues have been eliminated or still exist.

There still remains an opportunity to explore how we can help researchers, academia and gamers assess new research, and also universally optimize current on the market GaaS technology, with one unified tool to improve the GaaS gaming experience. Introducing the GaaS RATK.

The research is not to provide a complete solution to all problems with GaaS, but instead will set a foundation for research that will contribute to the solution of these ongoing issues. Ultimately, this type of application could be the starting point to future research and a conduit to perfecting auto-tuning, and adaptive tools for GaaS, and new implementation methods that would optimize thin-clients, eliminating the need or purpose for fine-tuning.

1.3 Objectives and Research Issues

This section reviews the three main research objectives of this thesis. To overcome the objectives, several issues will need to be resolved. Each objective can have one or more issues.

Objective 1: to implement an open hardware platform to utilize the tuning and diagnosis applications

This research will lead to the outcome of an open hardware device that will house the tuning and diagnosis applications, completing the GaaS RATK. The result of the combined objectives is the GaaS RATK.

Issue #1 (Hardware affordability and Right sizing issue, Section 4.1)

The open device that forms the toolkit will need to be powerful and affordable. Research and testing will need to be completed to make sure the device and its drivers do not have any flaws or performance issues that affect the quality of the GaaS research experience. The third party hardware components will need to be rightsized and affordable for the GaaS research tasks.

Objective 2: to implement a thin-client and a series of tuning and diagnosis applications.

This research will develop a thin-client that launches a series of tuning and diagnosis applications. This will provide a vehicle to assist in the discovery of new areas of research and ways to test and optimize new methodologies.

Issue #2 (Multiple platform target issue, Section 3.1 and Section 4.2.1)

Not all SDK`s and development frameworks are created equal. Therefore the toolkit must be unified and the core functionality operational on all target devices.

Issue #3 (User functionality Issue - Cross-platform API functionality, Section 3.3)

Native device API`s are not standardized on mobile devices. A core base of required toolkit functions will need to be assessed to see what toolkit features, can access a core set of hardware interfaces that exist on all devices. Research on how to connect a unified code base to native device API`s will need to be explored for core user toolkit functionality across all devices.

Issue #4 (Single code base compiler issue, Section 3.3)

Device and operating system specific SDK's, and their development environments will often have source code compilation errors. Even with a unified development framework, the research must include a way to streamline errors across all devices.

Issue #5 (Application accessibility and launcher issue, Section 4.2.1)

The toolkit interface will need to be able to launch, or in the least, loosely interact with the GaaS tuning and diagnostic applications. This research will need to find a way to accomplish this on devices that sandbox their applications from one another and the root file system.

Issue #6 (Acceptable GaaS experience issue, Section 5.1.1)

Operational baselines for acceptable functionality of GaaS will need to be established. When the measurement tools in the toolkit assess GaaS operational factors, a consistent quality of service will need to be obtained when the threshold is met (Qualitative baselines and thresholds). This also applies to the user experience. We need to measure or compare the thresholds against Phenomenology Qualitative measures to make sure the user experience falls in line with the Qualitative threshold of acceptable GaaS usage. When this problem is solved, we should see a consistent operation and positive gaming experience.

Objective 3: to confirm the effectiveness of the GaaS RATK

This research will confirm the effectiveness and functionality of the GaaS RATK by using quantitative research methods. The research will also strive to confirm the usability from the perspective of user perceptions and phenomenology via both qualitative and quantitative methods.

Issue #7 (Features, Functionality and Operational Issues, Section 2.1-2.4 and 5.21-5.2.3)

The research in this phase will measure the effectiveness of the GaaS RATK as a GaaS research facilitator. The research will define some key performance indexes like features, functionality, and performance (e.g., speed, accuracy, etc.) and make proper comprehensive comparisons between what the toolkit provides and the facts/data/needs/requirements mentioned by literature.

Issue #8 (User Perception and Usability Issue Section 5.1.2)

User experiences may vary. A results baseline will need to be established to measure user satisfaction with the GaaS RATK. A combination of usability analysis questionnaires and technology acceptance models will need to be designed.

Toolkit design objectives, issues and outcomes will be resolved and presented in Section 3.1, 3.2 and 3.3. Toolkit implementation objectives, issues and outcomes will be resolved and presented in section 4.1, 4.2 and 4.3. Research experiment design and outcomes will be presented in section 5.

1.4 Thesis Structure

Chapter I discusses the motivation, goals and the authors contribution to this research. Also discussed are the objectives and research issues in regards to GaaS. GaaS systems and their operational framework will be explained with references to historical and ongoing technical challenges and carry over issues. The last part of Chapter I, will explain the thesis structure.

Chapter II discusses previous related and relevant GaaS research works, with a focus on recent years as well. The main focal points for GaaS research works will be quality of experience, GaaS cognitive adaption, interaction delay and environmental perception &

emotional indicators. GaaS research and issues directly related to those four focal points will also be discussed, in regards to if they add more clarity to GaaS issues, research goals and outcomes.

Chapter III discusses the requirements and features of each component of the GaaS RATK with a focus on hardware, software and tools. This chapter also covers the GaaS RATK architecture and workflow.

Chapter IV illustrates the design and implementation of core components of the GaaS RATK including hardware, software and toolsets. Chapter IV also explains GaaS RATK with real world use cases.

Chapter V consists of the evaluation and discussion. The experiment, chosen research methodology and model are explained. Related research questions, hypothesis and questionnaire in regards to the research are also presented. At the end, Chapter VI presents conclusions, anticipated challenges, results and possible future work to be completed and or explored in relation to this thesis.

In Chapter VI, conclusions are drawn based on the data results, reflection and internal insight developed from the experiment. Next challenges and limitations are discussed. Upon conclusion of the thesis, any future work to be done is discussed for the GaaS RATK.

1.5 Terminology

API: Application Interface

AAA games: Big Budget Video Games developed by large commercial software development companies that strive to be of great quality for mass consumer consumption

Fps/ FPS – Frames per second / First Person Shooter

Frame Loss: When rendered GPU frames are missing in the GaaS Streaming process, due to lack of GaaS, network or GaaS Client optimization.

Frame Rate Issues: FR issues in GaaS is a phenomenon that occurs when the GaaS client cannot properly maintain a high quality frames per second count. Low FPS can cause gamers to have a poor QoE with video games. Some side effects are poor reaction time, headaches, nausea, dizziness and possible vomiting.

GaaS: Gaming as a Service

GaaS Errors: (Jitter, Stutter, FR issues, Frame loss, Screen Tearing) Errors that occur in Gaming as a Service games, that are agnostic to console and computing platforms.

Jitter: Jitter can be measured as latency that is inconsistent, that causes periods of packet burst or slowdown on a network. Inconsistent latency can produce odd anomalies in network and multiplayer games, this is especially true with GaaS, in which inconsistent video stream delay and unwanted screen artifacts can occur.

LAG: A network and gaming phenomenon that occurs that causes multiplayer network games to pause or freeze, making the onscreen player or environment to perform in unintended ways. This phenomenon destroys a player's reaction time in video games.

QoE: Quality of Experience

RTT: Round Trip Time

RATK: Research Assessment Toolkit

Screen Tearing: A video game display error that literally makes the objects and environments on screen look like they are tearing. The objects and environments on screen tear away from each other in several sections as the rendered objects move. Objects properly render again when there is usually no object or environmental movement (IE no input from player).

SDK: Software Development Kit

Stutter: Stuttering or Micro stuttering occurs when GPU or streamed frames cannot be accurately rendered on screen. In the GaaS World, this occurs when network conditions are not favorable or the GaaS Client itself has not been optimized or has a pragmatic defect. In this scenario the codecs cannot properly render the stream and video frames.

2 CHAPTER II – PAST RESEARCH WORKS

In this chapter a general background of previous and ongoing GaaS research work will be presented. Significant and relevant past research works will be reviewed in appropriate detail, to highlight its importance in relation to the current motivation and direction of this thesis proposal. GaaS design and implementation approaches from past research works are identified and discussed in the latter part of this chapter. The following subsections in this chapter will identify known related research literature and identified issues within the GaaS realm and their relation to the GaaS RATK (Section 2.1 – 2.4). The concluding subsection, will summarize the research works in detail, and provided thoughtful analysis of their subject matter (Section 2.5).

2.1 Quality of Experience (QoE)

Although the GaaS evolutionary curve has continued to evolve over a ten year period and ongoing, in many ways it is still in its infancy. One of the original and ongoing themes of GaaS research from inception to ongoing evolutionary reality is the concept of QoE (Quality of Experience). Howard et al. (2014), defines QoE as a set of metrics that represent a player's emotional, cognitive, and behavioral processes during GaaS activity. Metrics measurements on the functionality of GaaS as a whole are a part of this equation and have an impact on QoE, but one of the first questions that researchers posed, after implementing one of the first GaaS systems was, "How was your gaming experience?"

Slivar, Suznjevic, Skorin-Kapov, & Matijasevic (2015), approached QoE from a subjective perspective. A pre-survey was completed that consisted of an online questionnaire assessing a few main factors. The participants were asked about their previous gaming experiences, previous use of cloud gaming and how skilled of a gamer they considered themselves to be. As a part of the survey the participants demographics, gaming hardware, motivation for playing games and perceived notions of acceptable gaming delays were also collected. A mix of male and female gamers was chosen for the QoE experiment. Network conditions known to affect GaaS such as latency, ping time and delay were controlled and masked from participants so that the participants would not have any preconceived notions of a perfect GaaS scenario versus a challenged one. Participants then subjectively relayed their experiences based on their personal perspectives, indicating at certain points whether they would continue or quit playing the video games based on the current masked conditions.

Jarschel, Schlosser, Scheuring, & Hoßfeld (2013), utilized phenomenology and subjective participant input to determine the GaaS QoE. In (Jarschel et al., 2013) research, the users are subjected to a pre-survey to collect previous gaming experiences and demographics. Participants were subjected to a controlled lab environment, where all conditions were baselined, yet masked from the participants. Participants were given 10 minutes of free playtime on the GaaS system, under perfect network conditions, upon which without warning the lab GaaS environment was purposefully degraded. At this point, participant observation occurred, and users relayed their subjective and phenomenological experiences verbally to researches who recorded responses using the MOS (Mean Opinion Score) scale. The participants were allowed to choose their own MOS scale rating, based on their subjective and phenomenological experiences.

Howard et al. (2014), chose to measure a user's QoE, in relation to Lag, from a subjective perspective. It was noted that not only the lag of the underlying network, (whether local or cloudlet based), but also the lag of the weakest system co-operative link in the cloudlet, also causes QoE issues. Conclusions of this research link poor QoE based on technological factors to lack of adoption for GaaS.

The result of many of these approaches to QoE research was that most experienced gamers (the hard-core gamers that would be most likely to utilize subscription GaaS), are unwilling to use GaaS platforms under degraded conditions. Specifically it is noted that degraded QoE will affect future GaaS technology, research, implementation and their adoption (Howard et al., 2014). All the QoE literature results reviewed, span a period of 2006 to 2016.

Related to QoE, GaaS System and network issues are latency, delay, jitter, stutter, lag, packet loss, frame drop and total blackout. The source of these errors can be the GaaS System itself (server or client), the local, cloud or cloudlet network. There has been much research focus on how GaaS systems and network degradation effect gamers, and specifically researchers have tried to quantify if certain isolated system components are more at fault than others. A secondary source of contention, in regards to GaaS is the proliferation and popularity of wireless. Cai, Leung, & Chen (2013), acknowledge that GaaS over wireless is extremely RTT-sensitive (round trip time). It is also acknowledged that the RTT's of mobile devices are sensitive to geographical dispersion in regards to packet loss and hop-count when trying to maintain contact with GaaS cloud servers (VM's). Cai et al. (2013), theorized that a series of slave cloudlet servers in closed geographic proximity could possibly solve some of the quality and network loss issues. However it should be noted, that they also acknowledge that due to the nature of mobility issues involved, it would be very hard to design a successful cloudlet model to remedy the stated GaaS issues. Cai et al. (2013), conclude that cloudlet research as a solution to wireless GaaS and network issues should remain open for future refinement and research studies.

Lee, Chu, Cuervo, Wolman, & Flinn (2014), study the effect of wireless wide-area latency on GaaS. In their research they acknowledge historical GaaS issues, including RTT's in regards to mobile devices and GaaS. Lee et al. (2014), accept in their research that real-time interactivity means that client input events should be reflected quickly on the client display. It is also discovered in their research that players are sensitive to as little as 60ms of latency, and latencies in excess of 100ms or higher only serve to aggravate the GaaS degradation problems further. Lee et al. (2014), show that delay degradation from 150ms to 250ms leads to 75% user engagement loss. In their research work, various methods of GaaS cloudlet and server edge server methodologies are acknowledged as possible solutions to this problem. In the end, they cannot sync user RTT mobility issues with cloudlet based methodology, further acknowledging the large cost factors of decentralized edge servers. Furthermore it is accepted that local spikes in demand cannot be routed efficiently to edge servers, which once again magnifies the cost and viability.

Another very important aspect to Lee et al. (2014), work in regards to GaaS system and network degradation is that the 95th percentile of 3G and 4G network latencies are over 600ms, with most of the latencies occurring in the last mile. It becomes clear that this is well out of the acceptable delay range for GaaS and a user's QoE. This may be okay for buffered non-interactive video streams, but it becomes clear that GaaS cloudlet solutions, other network degradation and masking delay methodologies still have room for further research exploration. Internal software issues and a lack of optimization have also been linked to QoE.

GaaS literature and research has explored possible internal software issues and lack of optimization among systems. Xue et al. (2015), discovered internal software issue's in some GaaS systems such as queuing. The queuing system itself was meant to unload some of the burden off of the GaaS edge servers. Unfortunately it becomes clear that the queuing system became a software issue, and an optimization issue. The queuing system was not intelligent enough to efficiently deliver load, and was not optimized to take advantage of edge servers. Xue et al. (2015), concluded that a more intelligent request dispatching strategy may be needed. Shea, Liu, Ngai, & Cui (2013), accept in their research that the internal GaaS system framework itself can also be at fault for ongoing GaaS issues. As an example they endeavor to study the GaaS client and its H.264 compression techniques. They quickly find out that due to the lack of optimization and customization settings, that the thin-client's compression techniques suffer considerable degradation with bandwidth fluctuations. Specifically stated, they note the effect on compression is quite noticeable, especially as the available bandwidth decreases. This literature is of particular value as it shows there is room for possible short term and long term improvement for the GaaS software issues and optimization research. In the next section, we explore adaptive methods that try to solve the GaaS QoE, software error and optimization issues.

2.2 GaaS Adaptive Systems

In recent years, researchers have attempted to implement GaaS adaptive algorithms that try to adapt automatically to a gamers system, environment, network and gaming conditions. Cai, Zhou, Leung, & Chen, (2013) experimented with a cognitive gaming platform that utilized information collectors, that send data to a performance evaluator and local analyzer, in an attempt to assess a gamers GaaS resources. Agents autonomously flowed between the client and the server delivering these measuring components as needed.

After the data was analyzed, Cai, Zhou, et al. (2013), used a Partitioning Coordinator to intelligently select destination components regardless of if they were local or remote to implement dynamic resource allocation. In the final steps a Synchronization Controller attempts to ensure that all data in the cloud and client are identical and correct for their relative components. By their own admission, Cai, Zhou, et al. (2013), state up front that partitioning schemes are not a one size fits all endeavor, so they cannot be aligned to all systems equally, even if an adaptive algorithm is utilized. Dynamic partitioning mechanisms are not ubiquitous or interchangeable in any manner. It is explained that there is not a universal standard or application for partitioning solutions. A partitioning solution must be designed specifically for an adaptive cognitive solution. In the end this leads to more overhead and complexity for GaaS.

Stavert (2016), performed research on the improper allocation of resources when using adaptive solutions. AAA video game titles, that only run on high end PC's or video game consoles, are usually seen as having high specifications and being resource rich. Mobile devices usually do not have the hardware power or capacity to run AAA video games. AAA games are also seen as blockbuster hits that are required to sell and review well. An example of a AAA video game, would be Grand Theft Auto 3-5. The experiment took several AAA market titles and applied an adaptive GaaS client to them. In this particular experiment, it became apparent that the client consistently and inaccurately detected poor network conditions, which led to frame skipping, packet loss, jitter, stutter, blackout and a phenomenon called screen codec bleeding. It was noted that in this particular experiment, it was better to statically assign GaaS resources for a better QoE with GaaS.

Chi, Wang, Cai, & Leung (2014) perform some compelling research that involves Cloudlet Ad-Hoc co-operative gaming, combined with task scheduling and an adaptive approach. In this research, clients connect to the cloud and local cooperative ad-hoc cloudlet clients dynamically. This method utilizes the power of the cloud, as well as the untapped hardware power of client resources. It endeavors to dynamically, and adaptively assign and load balance the cloud and ad-hoc cloudlet resources. The complexity of this scenario is elevated when one considers that not only are the researchers using task algorithms to balance resources among the cloud and ad-hoc cloudlet, but also utilizing adaptive technology to apply partition schemes that dynamically allocate raw GaaS system resources among many ad-hoc clients. Figure 1 shows the GaaS game being progressively downloaded from the server and shared among the cloud GaaS server farm, and the cloudlet (gamer's computers), forming an ad-hoc cloudlet, where the clients become a part of the GaaS system. We can also see tasks being load-balanced across the cloud and its clients.

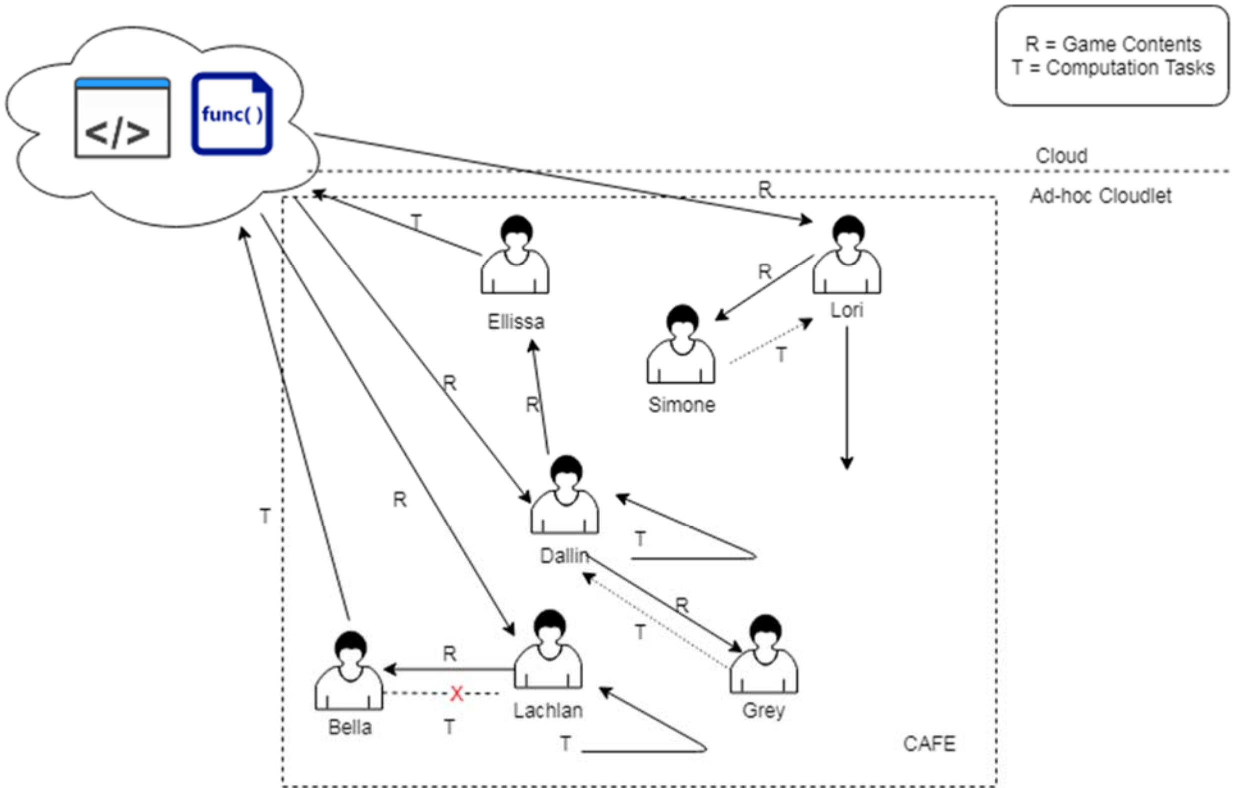


***Figure 1.* Co-operative Ad-hoc Gaming**

```
Algorithm Frame for Task Allocation
T := Task Sets
M := 0
for i ← 0 to N do
    choose{u ∈ neighbourOf(initiator(Ti))};
    if u ≠ Null then
        M := M ∪ {Ti, u};
        Cu := Cu - CTi ;
        Su := Su – Sti;
    else
        Of floadToCloud(t)
    end if
end for
```

Figure 2. **An algorithm for task allocation in cloudlet ad-hoc gaming.**

In Figure 1 the symbol R represents the game contents and T stands for Tasks. The flow arrows show game data going to and from the cloud, as well as the flow of tasks among clients and the cloud. In Figure 2, we see a basic breakdown of the task scheduling and allocation algorithm that is used to divide GaaS system tasks among the ad-hoc cloudlet, based on if the client is online and available. If one of the ad-hoc cloudlet members is not available, the algorithm tries all next neighbors, and if it can't find a viable online neighbor, the algorithm offloads to the cloud.

There is a resource cost and complexity to adaptive GaaS solutions that take away from the already strained resources that are needed to have a positive QoE with GaaS. It is acknowledged that partitioning schemes and algorithms are not a one size fits all solution. It has also been shown, that if there are algorithm errors in the adaptive process, it would actually lead to a worse QoE in GaaS, than if the resources were statically applied. As a result there is a strong argument to be made for a research assessment toolkit, that facilitates static GaaS system resource and optimization, while the GaaS adaptive research evolves.

In the next section we talk about the research performed on solving ongoing QoE issues with interaction and end to end delay.

2.3 Interaction and End to End Delay

Zhang, Qu, Cihang, & Zheng (2016) explain that the most fundamental form of GaaS is defined as direct and on-demand streaming of games to network connected devices, where the game is actually running on the server.

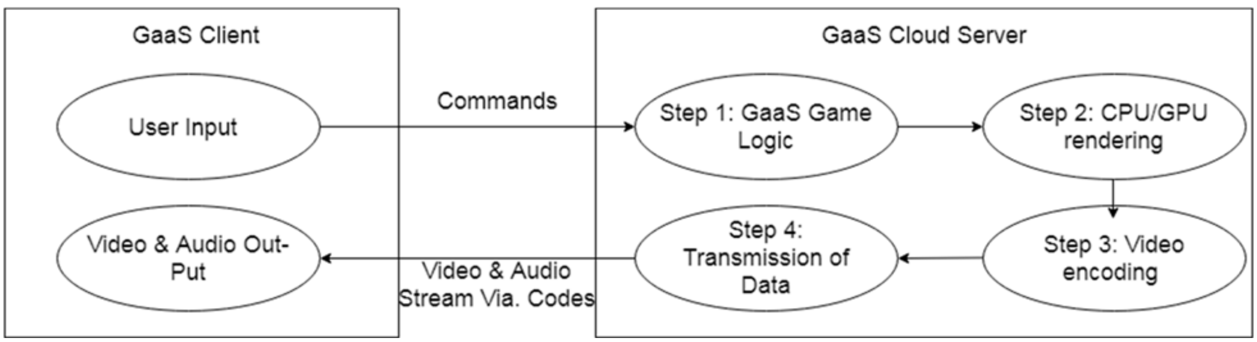


***Figure 3*. The whole workflow of cloud gaming.**

Figure 3, is an example of the whole workflow of cloud gaming. An acknowledged problem in this scheme is interaction delay. As noted in previous sections, unless a gamer can respond within a 60ms window to modern FPS and time sensitive games, they will not have a positive QoE. Several researchers have attempted to solve or lesson the interaction delay problem. Shi, Jeon, Nahrstedt, & Campbell (2009) proposed a project that would allow for 3D accelerated remote rendering on the server system only relaying the flat 2D streaming image, back to the client. A custom non-standardized algorithm was used to accomplish this task. In the experiment, 3D warping was proposed to minimize the problem of interaction delay. A resulting complication in this scenario was the fact that since the image stream itself was 2D, increased interaction delay occurred when the user needed to change the viewpoint of the 3D render, on the client side. An acknowledged limitation within this scenario was the fact that a new RTT loop was introduced to render the 3D object from the new viewpoint, which in-turn led to increased interaction delay.

Shi et al. (2009) communicated another issue that was directly related to interaction delay within their research. It became apparent that this scenario only allowed for a framerate of 15fps. VBDude (2007) on Tom's Hardware Guide explains that the industry standard frames per second that most gamers are willing to tolerate are 30fps, with 60fps considered to be excellent. It is also noted that with FPS games that require a fast paced twitch response, anything less 30-60fps causes unnecessary interaction delay, since it is inherently slowing down a fast paced action game. Gamers have already acknowledged their dismay with localized PC and console gaming that does not adhere to this standard, and interferes with the QoE. The resulting notion is that GaaS systems should attempt to strike on or above this frames-per-second mark, to encourage acceptance of GaaS systems.

Tian, Wu, He, Xu, & Chen (2015) implemented a GaaS solution with a goal to achieve cost affect adaptive cloud gaming across geographical dispersed datacenters, while also attempting to limit interaction delay. Several new algorithms were streamlined to make the adaptive task more flexible and efficient. To accomplish this task Tian et al. (2015) utilized the Lyapunov optimization theory. The main benefit of the Lyapunov optimization theory is that no prior knowledge of the gamer's behavior, or their environments are needed to optimize the algorithm for GaaS QoE.

To reduce costs, the algorithms will also default to the least needed resources scenario to satisfy cost efficiency. However, if noticeable QoE constraints are encountered based on algorithmic thresholds, the adaptive system will default the other way. This is done to dole out as much resource as needed to, satisfy GaaS needs. The designed algorithms can also spin VM's up and down as needed. As a result, environmental scenarios that encounter extreme interaction delay can affect the cost effectiveness of this adaptive system. Tian et al. (2015) acknowledges that they implement a good enough philosophy in this QoE scenario, in an attempt to satisfy cost-effectiveness and interaction delay. As a result of these statements, and the extremity of Tian et al. (2015) and their algorithm calculation, when interaction delay remains unsatisfied there remains room for research of static optimization of the GaaS client and services using guided resources such as the GaaS RATK.

Amiri, Osman, Shirmohammadi, & Abdallah (2015) proclaim that interaction and end to end delay, is a formidable enemy in regards to modern GaaS gaming. Amiri et al. (2015) suggest that GaaS has approximately 1.7 times higher latency than traditional localized console based gaming. It is expressed that these latencies will directly affect gamers QoE, while compounding issues with integration and end to end delay.

Amiri et al. (2015) indicate that only 70% of gamers have the resources to meet the 60 – 80 ms latency target required for a positive GaaS experience. As a result of this Amiri et al. (2015) propose a Software Defined Network (SDN) Controller to reduce interaction and end to end delay. In their research, they believe that an SDN could be more efficient than the traditional Open Shortest Path First (OSPF) method for reduction of global GaaS system delay. As an experiment Amiri et al. (2015) implement an OpenFlow SDN controller. It is proposed that traditional and modern networks do not take into account the modern day methods and protocols used in GaaS.

In general it is proposed that routers and switches choose the best path for traffic based on traditional methods and protocols. Even after taking into account the sharing of their routing tables. In fact it is pointed out that these switches and routers, when deciding the best path, and least path of resistance for traffic, still operate autonomously in this decision, even when shared routing tables are involved. The researchers also attempt to show that a device such as an SDN controller has several benefits in regards to GaaS gaming.

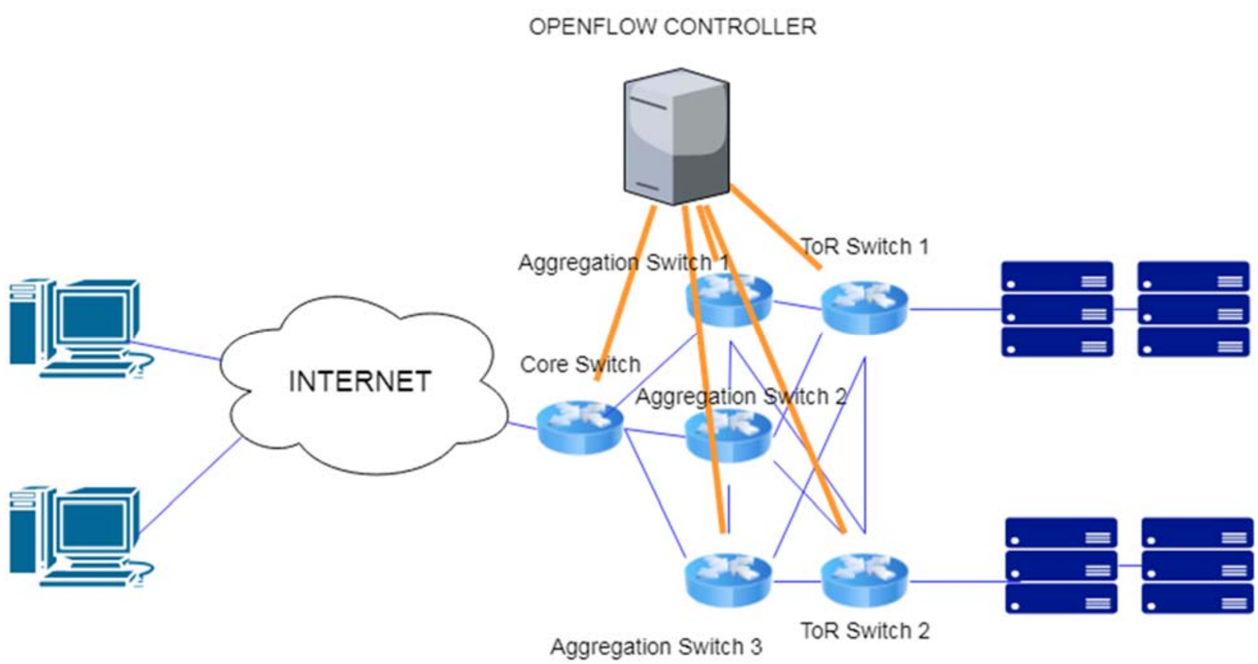


Figure 4. **SDN Cloud Gaming Architecture.**

Figure 4, represents the SDN Cloud Gaming Architecture. It is stated that an SDN does not operate autonomously, but instead decides the best route and load balancing for traffic, because it can look at all traffic at once; while sharing information with other higher level networking devices. The proposed result of this, is that an SDN can make a much better gatekeeper and conductor of traffic since all information flows to and from it, in the decision making process. It should also be noted, that the SDN understands the modern day protocols used for GaaS and as such it utilizes them in a more efficient manner. In theory this makes the load and balancing of traffic more efficient.

Amiri et al. (2015) acknowledge early on, that there is a high computational cost for the algorithms that perform these traffic flow and load balancing tasks. It is also stated that some of the adaptive algorithms used do not produce optimal traffic distribution. Another attempt at improving the QoE in GaaS is environment perception and emotional indicators, which we talk about in the next section. This research also endeavored to solve other related legacy technical and GaaS system issues by measuring a user's emotional and physiological responses.

2.4 Environmental Perception and Emotional Indicators

GaaS research has explored how emotional perception and emotional indicators can be used to measure, quantify and improve the GaaS gaming experience. Lee, Chen, Su, & Lei (2012) conducted an experiment to see if all video games are equally GaaS friendly. Nine games were tested for their vulnerability to latency and QoE degradation. To help initially determine QoE, so that a model could be developed, the gamer's emotional indicators were measured using facial electromyography (fEMG). Lee et al. (2012) realized early on that certain games are more susceptible to latency and QoE degradation than other games. As a result of this research, and the cost of QoE measurement in GaaS games, a model was developed that calculates the real-time strictness of games (RS). Real-time strictness measures a game`s QoE degradation in relation to the amount of latency present in regards to the user`s input response cycle. The goal of the research was to have a model that would allow pre-measurement of a games cloud-friendliness, without having the cost of QoE measurement. It would also provide developers and GaaS system implementers the opportunity to pre-optimize a game for GaaS use. There is however still a cost to optimization of code, as well as system costs when pre-optimizing data center hardware.

Hassan & Alelaiwi (2015) conduct an experiment which uses an emotional engine to measure a user's emotional response and perception of GaaS games. The user's emotions are recorded using camera mounted displays, and processed through an engine that scores the emotional weight based on Gaussian mixture models (GMMs). Unique scores are given to positive and negative emotions, based on the GMMs, so as to computationally identify the difference between a positive and negative emotion.

The emotion engine then processes the GMM score. Then based on the threshold and unique values assigned to the emotion, attempts to display a random screen effect, based on the GMM scores. The screen effect attempts to rouse a more positive and emotionally engaged gamer. In short, the goal is to turn a gamer's negative emotions into positive emotions by adjusting and outputting screen effects and features, until the gamer is satisfied with the GaaS system. This system investigates emotional response based on auditory (MPEG 7 descriptors) and Image Frame-Based Emotion Recognition.

A point of reference for this model should be taken from computer based speech recognition endeavors. To show the correlation, one should take into account that the emotional engine needs to be trained, much like early implementations of speech recognition. An undescribed amount of time must be carefully taken to train the system to recognize the extremes and physical differences of each user's emotional responses. The system also needs to calculate which scene effects produce positive emotions, and which ones produced negative ones. This emotionally aware GaaS research is to the author's knowledge, the first of its kind, and through the authors own words, is in its infancy, in regards to research and development. In this section, it may also prove important to explore the flow theory in relation to environmental indicators and emotional perception.

Mirvis, Csikszentmihalyi, & Csikzentmihaly (1991) state that the Flow theory was first discovered by Mihaly Csikszentmihalyi. Soutter & Hitchens (2016) explain the Flow theory or flow for short is described as being a state where one is so involved in a task, that you feel energized, fully involved and are receiving enjoyment or utter happiness. In the gaming world, this is often referred to as being, "*in the zone*." Often when flow occurs within gaming, gamers report a feeling of euphoria or well-being, feeling ultimately engrossed and not aware of one's surroundings. Chen (2007) expressed the idea that although flow is subjective to each participant, it should be noted that it is not always related to optimal performance. Flow can occur among gamers in games with simple tasks such as exploring environments, and jumping around on platforms.

Although flow is something that can reasonably exist in video games, most of the flow research focuses on PC gamers, browser based games and video games systems hooked directly up to a TV in a home setting. Flow theory in video games is directly related to a particular game itself, and how much flow it can induce based on the games active rules.

Chen (2007) explains three main features in a game must exist for flow to occur. The game must be rewarding, the game must challenge the gamer's ability, just enough, and the gamer needs to feel a sense of control over the gaming activity. When testing a game for these flow features, a specific game must be chosen as a part of the test, and it must meet the requirements stated above. Since flow is somewhat subjective, we would also need to know if the gamer felt any of the symptoms of flow, and if flow was encouraging the gamer to play the game more. To date, the author has been unable to find any GaaS related research on how carry over issues within GaaS directly affect the identification of flow. The GaaS errors would have to be eliminated within reason, and then some flow framework theory would need to be incorporated into the post questionnaire. As a result, if scope and time permit, the theory of flow may be identified within the questionnaire framework to see if it exists among gamers. Due to the shear scope of Flow Theory, gaming and GaaS, it would be better served in the future work to be done on the GaaS RATK.

2.5 Summary of Past Research Works

In regards to the above research works, and other similar research studies (Ewelle, Francillette, Mahdi, Gouaich, & Hocine, 2013; Lin et al., 2014; Liu, Dey, & Lu, 2015; Shea, Fu, & Liu, 2015; Stavert, 2016; Wang & Dey, 2010; Xu et al., 2014) a general epitome has been constructed below:

1. QoE whether measured quantitatively or qualitatively remains open for improvement. Past and current research shows that gamers will not accept a degraded or un-optimized experience that is a step down from localized gaming. There is a correlation between user acceptance of GaaS and QoE (Slivar et al., 2015).
2. System and network degradation and a lack of optimization and loss, coupled with poor RTTs, especially when wireless networks and devices are introduced; leave room for assistive tools for testing and optimizing new research and methodologies (Cai, Leung, et al., 2013).

3. Internal programmatic issues and errors can exist on the server and the thin client when utilizing GaaS. In recent research, the thin client itself has been tested, and has proven to be a source of error that can cause lag, jitter, latency, stutter, blackout and optimization issues (Claypool, Finkel, Grant, & Solano, 2014; Stavert, 2015; Tan et al., 2010).
4. Research has shown that adaptive optimization of resources for GaaS looks promising; unfortunately it also shows that adaptive measures for GaaS are not a, “one size fits all” solution. It has also been shown that adaptive technology can be costly and error prone when it assigns or schedules too many or too little GaaS system resources based on internal algorithms. Adaptive technology has also been known to introduce unpredictable and random errors in GaaS, because algorithms are not always a one size fits all solution to environmental anomalies (Hong et al., 2015; Tian et al., 2015).
5. Admirable research experiments have been applied to GaaS in an attempt to resolve interactive and end to end delay, yet due to the large amount of variables involved it still remains an issue (Amiri et al., 2015; Semsarzadeh, Yassine, & Shirmohammadi, 2015; Zhang et al., 2016).
6. Research into emotional indicators and environmental perception as a tool to adapt or improve GaaS has been carried out. Specifically, the research itself is in its infancy. As a result current emotional engines require an undetermined length of time for training and adaptions, to physical and auditory emotional response. The current state of emotional processing engines remains at odds with the current goal of GaaS, which is instant gaming gratification on any device anywhere.

However as technology and emotional engines evolve through research, the gap between GaaS and emotional engines will bridge itself (Hassan & Alelaiwi, 2015).

In summary of the above observations, it becomes clear and apparent that there is still room for static and assistive systems to test and improve methodologies, in regards to the evolution and optimization of GaaS. As a result there is much room for a multifunction and assistive Research Assessment Toolkit with a collection of unified and centralized software assessment tools to help test and evolve GaaS. Although adaptive technologies look promising, there is still a place for static and manual optimizations for immediate improvement of GaaS while other methodologies are evolved and tested.

3 CHAPTER III – REQUIREMENTS ANALYSIS

The following is a breakdown of the requirements for the GaaS RATK. In this section the GaaS RATK requirements, features and components are analyzed. In addition there is an itemization of the hardware, software and tools. The architecture and workflow of the GaaS RATK will also be discussed.

In most cases the GaaS RATK endeavored to be a complete package that runs standalone. However there may be cases, where the use of an extended dashboard can be used to launch centralized assessment tools, or possibly an extended version of them. This is made possible when the API of the device the GaaS RATK is running on is not highly sophisticated or too restrictive. One may also need to launch the GaaS RATK on a more sophisticated device for data entry and assessment (i.e., a device that has a full keyboard, with higher specifications). There may also be research scenarios that require a fully rooted hardware device, so that the researcher can interact directly with the file system and hardware to see the exact interaction between the GaaS thin-client and the GaaS system itself. A standard vanilla mobile or set-top box that is un-rooted, may not allow tools to access the system files to run.

3.1 The GaaS RATK Requirements

The hardware for the GaaS RATK provides a great proposition for researchers and gamers on a budget. In scenarios where the user needs an affordable device that can run the toolkit and also run a GaaS thin-client to play games, the GaaS RATK can be bundled with a single board microcomputer. The single board microcomputer is ARM or Intel based and runs Linux as its main operating system. The hardware device has built-in 802.11 wireless, Ethernet, quad core CPU or higher, 2 GB ram minimum, USB ports, eMMC flash storage, onboard 3D video accelerator (Mali based), and support for HDMI displays. The device comes pre-rooted to allow users to focus on the use of the GaaS RATK tools, rather than having to perform extended technical tasks outside of the realm of assessing a GaaS system.

From a global perspective the hardware and specialized GaaS assessment tools combine together to form the GaaS RATK. The GaaS RATK has many uses among researchers, game players and developers. The following is a general global view and component breakdown of the GaaS RATK, and how it may be utilized by its user groups. A more in-depth, framework focused breakdown of the GaaS RATK and its core usages are presented later in Chapter 4.

It should be noted that the GaaS RATK runs on MacOSx, Linux, Windows, iOS, android and embedded Linux single board microcomputers. Globally the GaaS RATK components consist of the following, please see Figure 5.

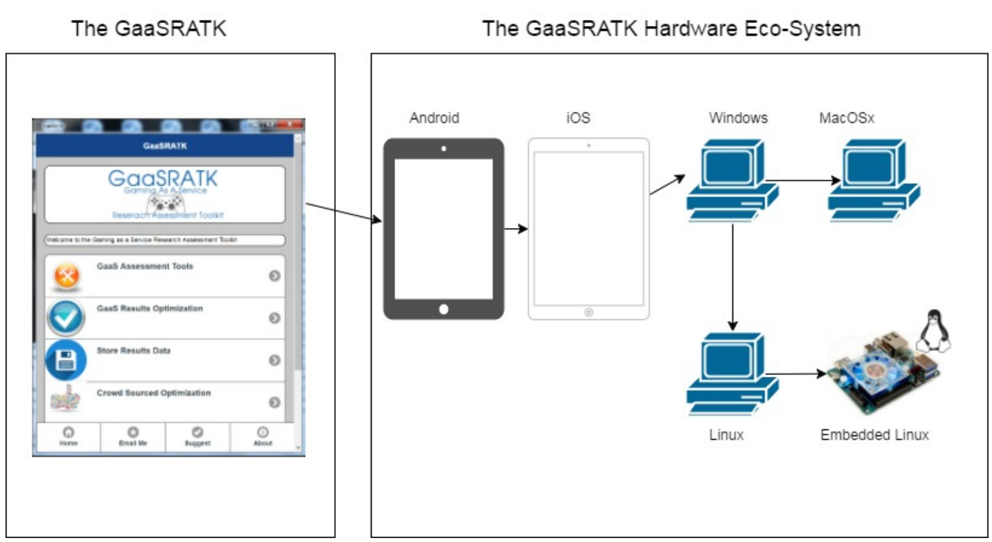


***Figure 5*. The GaaS RATK**

On the desktop all features of the GaaS RATK are fully functional within the specified working parameters. Since there is limited API accessibility and interaction to the file system and hardware on iOS and android, the assessment tools are limited on these two mobile platforms. Users can enter data for test and known working GaaS configurations and search for GaaS configuration settings. The embedded Linux and the highly portable single board microcomputer offering that is a part of the GaaS RATK, provides a cost effective and portability offering that the mobile gaming community has come to expect. The Android and iOS version consist of all of the valuable data management tools. The desktop and embedded versions of the app are the most functional.

The GaaS RATK components interact as detailed in Figure 6. The GaaS RATK software interacts with the hardware network stack and the devices application interfaces to provide access to the systems hardware components.

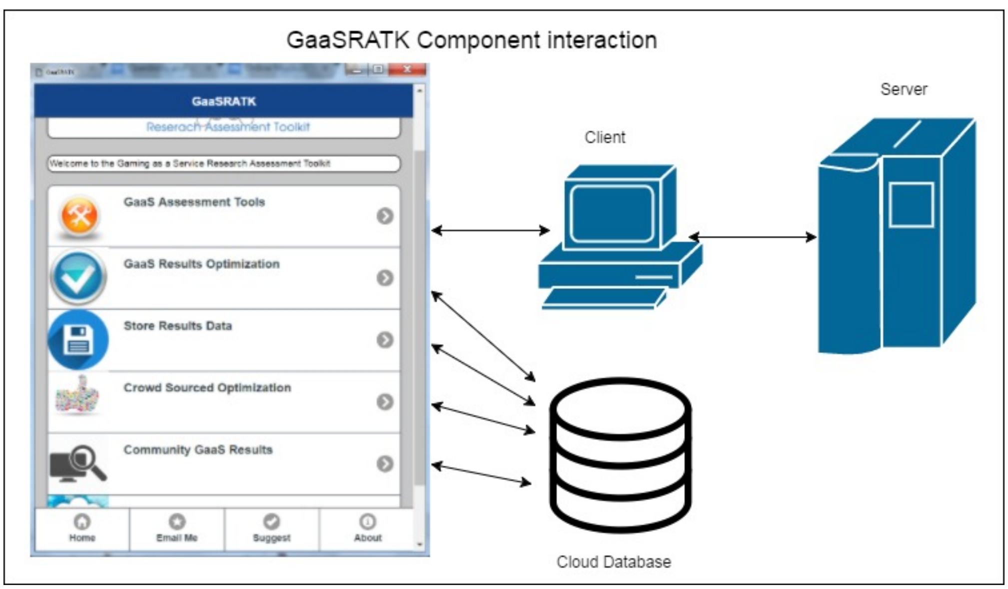


***Figure 6*. GaaS RATK Component Interaction**

The Assessment tools directly interact with the system network layer and file system to assess and dump performance levels of the hardware as it interacts with the GaaS thin-client and server. The GaaS RATK thin-client function directly interacts with the GaaS Server from the supported operating system and hardware. The thin-client launches GaaS Games with test settings which are chosen by the user with the assistance of the GaaS RATK assessment tools. The GaaS RATK thin-client is integrated into the GaaS RATK so that assessment tools can be run as the thin-client is launched on the hardware. The GaaS RATK thin-client is able to be launched in windowed and full screen mode so that interaction with the assessment tools can occur by the user.

Referencing Figure 7, researchers can use the assessment tools located in the GaaS RATK to test their GaaS innovations, to see if they are providing a positive QoE for the user while providing the optimizations expected.

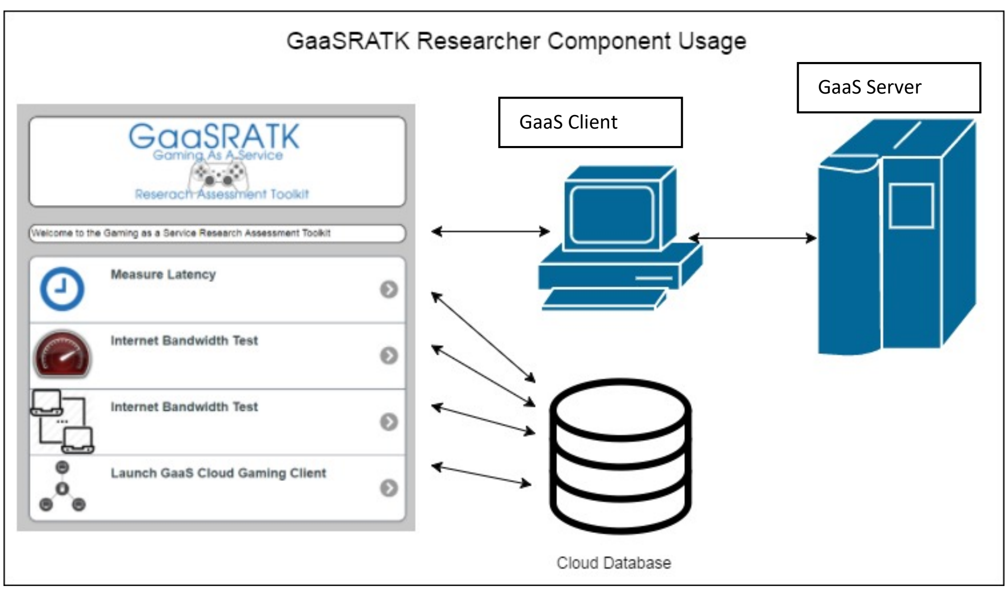


Figure 7. **GaaS RATK Researcher Component Usage**

A developer can use the GaaS RATK to install the game that is in development and see how well it is optimised for GaaS as Figure 8 shows. The developer can install their games and use the entire integrated server, GaaS thin-client and assessment tools, and assesses their games for GaaS readiness.

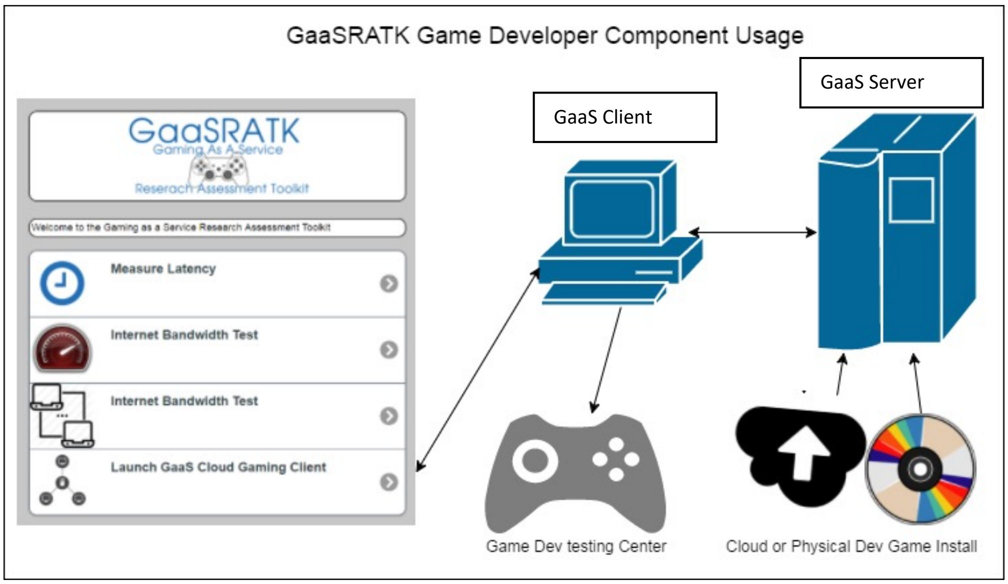


Figure 8. **GaaS RATK Game Developer Component Usage**

Players can focus on the GaaS RATK thin-client to test GaaS settings and to play and optimize their gaming experience.

3.2 Functional and Non-functional Requirements

The GaaS RATK includes latency measurement tools, packet and protocol identification tools, wired speed test, Wi-Fi speed test (properly over the air), ether-ape (Ethernet traffic identification tools), and the ability to launch a GaaS system thin-client for testing purposes.

3.2.1 Functional Requirements - Software

The functional requirements for the GaaS RATK include:

Requirement #1. The user shall be able to run GaaS system assessments based on a centralized set of GaaS measurement tools.

Requirement #2. The user shall be able to input and archive basic tests results. The Research Assessment Toolkit sends the data to a centralized cloud based database for future query.

Requirement #3. The Research Assessment Toolkit automatically outputs baselined optimized potential GaaS settings to improve GaaS QoE, based on manual entry of testing value thresholds.

Requirement #4. The Research Assessment Toolkit allows the user to contribute to a crowd sourced optimization setting repository (database). The results are stored in a centralized database that are queried read only, so that other users cannot edit another's optimized settings.

Requirement #5. The Research Assessment Toolkit allows for up or down voting of crowd sourced configurations, for the natural certification and accuracy of settings.

Requirement #6. The Research Assessment Toolkit allows the user to enter anonymous test results into predetermined fields for future and historical GaaS research purposes. The data is stored in a centralized cloud database that is a part of the ecosystem for the GaaS RATK.

Requirement #7. The user is able to read only query all centralized GaaS RATK testing results, to assist and evolve their current GaaS Research.

In the following subsections, 3.2.1.1 – 3.2.1.6 a further design explanation and breakdown of the software requirements and how they should perform within the requirements process is explained.

3.2.1.1 GaaS Assessment Testing

The user is able to run a series of tools that will allow for GaaS assessment testing. The GaaS RATK tools consist of the ability to measure latency, internet speed from GaaS client and server and direct on LAN GaaS client to GaaS server speed in Mbps. Once test results are received and baselined, optimized potential settings are explored the built in GaaS client can be launched with the optimized settings to see if there is an improvement in the gamer's experience. Cloud based data collection is built in. It is important for users of the GaaS RATK to be able to enter test results for future or historical assessment purposes (i.e., seeing the effectiveness of GaaS evolutions or improvements). It is also important to be able to apply these results to the GaaS RATK, so that results can be assessed and the GaaS RATK can have optimized GaaS settings.

All data is stored in a centralized cloud based MariaDB open source database that only allows users to access non-sensitive data. The credentials for accessing the database are encrypted and stored on the server in which the MariaDB database is running. Authentication or credential requests are made directly from the client (i.e., browser or mobile app) itself. The client only initiates a connection with the connector webpage on the server and the connector can initiate the database query request.

3.2.1.2 Cloud based Data Collection

Cloud based data collection is implemented. It is important for users of the GaaS RATK to be able to enter test results for future or historical assessment purposes (i.e., seeing the effectiveness of GaaS evolutions or improvements). It is also important to be able to apply these results to the GaaS RATK, so that results can be assessed and the GaaS RATK can have optimized GaaS settings.

All data is stored in a centralized cloud based MariaDB open source database that only allows users to access non-sensitive data. The credentials for accessing the database will be encrypted and stored on the server in which the MariaDB database is running. No authentication or credential requests are made directly from the client (i.e., browser or mobile app) itself. The client only initiates a connection with the connector webpage on the server and the connector can initiate the database query request.

3.2.1.3 Optimized Static Feedback

This component assesses specific user's inputs and produces optimized GaaS settings based on the GaaS system thresholds that are identified during assessment testing. The inputs for example could be actual speed of the system, and real latency from the assessment results. The purpose is to attempt to quickly improve the user's QoE. The following list is a description of how the Optimized Static Feedback component works.

1. There are input boxes for the user to enter specific GaaS assessment results.
2. The user can input the assessment results of their choice, generated by any of the assessment tools he or she used. The results are automatically dumped during testing, and can also be uploaded to Google Drive.

3. The system will attempt to produce suggested optimized settings that are compatible to the users' current GaaS RATK assessment tool outcomes and system capabilities. The suggested results can be tested on the built-in GaaS Client.

The GaaS RATK endeavors to provide accurate optimized configurations based on previous GaaS Testing. Results will only be as accurate as a user testing configurations on a GaaS system that is comparable to the tested configuration scenario.

3.2.1.4 Crowd Sourced GaaS Optimization Repository Contribution

1. The GaaS RATK depends on crowd sourced tested configurations. Users can use the assessment tool to test their GaaS system or research. A user can choose to, enter the results into the publicly searchable Crowd sourced configurations. The GaaS RATK needs to allow users to manually enter GaaS settings based on the assessment results and the user's current configuration.
2. Other users can search for a configuration that is close to their current GaaS configuration and apply the optimized GaaS configuration to their GaaS system, in an attempt to provide a higher QoE.

3.2.1.5 Crowd Sourced Certification

A natural crowd sourced certification occurs via a voting system that allows for the working or not working vote. If the crowd sourced configuration works on more than 10 GaaS User systems the configuration will automatically be deemed as certified. The workflow (see Figure 10) for the crowd sourced certification has six steps:

(1) The user enters the search terms that match the GaaS System they want to configure.

(2) The records in the crowd sourced database are queried for configurations that will help the user configure their GaaS system.

(3) The user must now test the settings on their GaaS system to see if they work

(4) The user votes on if the configuration was working (is it useful).

(5) Depending on what the user chooses, the configuration may become certified, or remain uncertified.

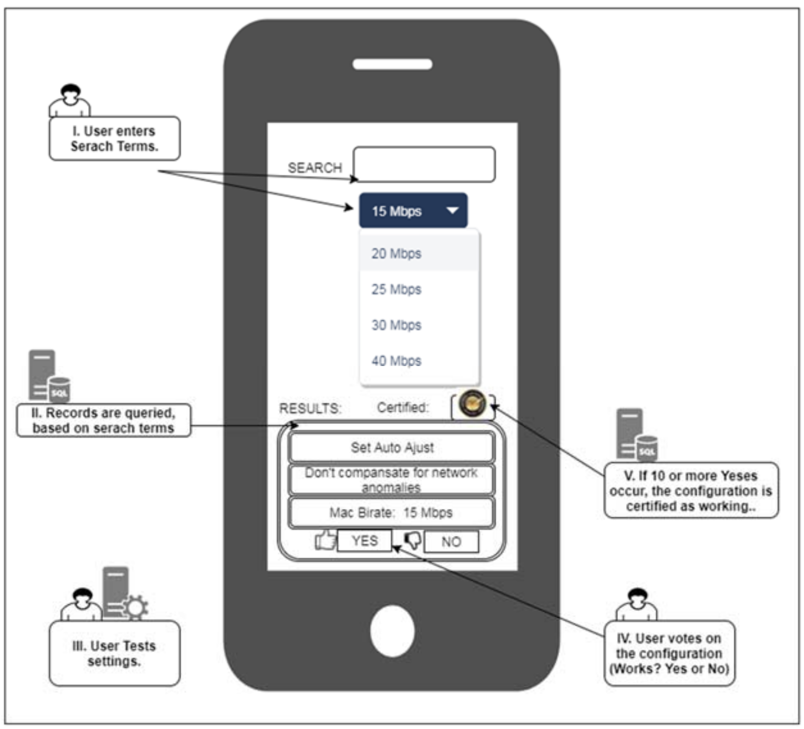


***Figure 9.* GaaS Crowd Certified Configuration**

Figure 9, represents the GaaS Crowd Certified Configuration.

3.2.1.6 Long Term Anonymous Archival of Test Results

As a part of the design of the GaaS RATK, a future scoped goal would be to assess the feasibility of anonymous long term GaaS assessment and testing results.

1. Assessment tool data should be exported and saved automatically. Local and cloud archival of results will be offered.
2. Users should be able to do a custom search for GaaS RATK configuration settings with advanced criteria.
3. Users may have the option to print out or save the configurations as a PDF file for future reference.
4. Users should be able to search optimization settings in the GaaS RATK at any time.
5. A standardized dashboard may be applied for ubiquitous device access.

3.2.2 Functional Requirement – Hardware

The functional requirements of the offered hardware device are:

- The device is an all-in-one single board microcomputer.
- The device has the ability to run embedded.
- The device has an on-board 10/100/1000 LAN port.
- The device has on-board and USB ready 802.11 wireless with the potential for [802.11 ac standard] speeds within the 5-GHz range standard for a better GaaS QoE. USB allows for future wireless speed upgrades.
- The device has supported Bluetooth capability with some proven support for Bluetooth soundcards, headsets, brand name game controllers, keyboard and mice devices.
- The device has a robust on-board video acceleration card, which supports both 3D graphics and video acceleration. OpenGL acceleration is a requirement as well,

the on-board accelerator has good driver and API support for the hardware it is on.

- The device has a quad or octa-core CPU on board.
- The device has support for eMMC 5.0, SATA or Flash storage.
- The device has HDMI video out.
- The device has on-board sound, and digital or analog out port.
- The core unit outside of LCD and battery accessories is affordable, so it costs between the $50 – $200 range, depending on features and accessories. The affordable price allows for an affordable dual purpose GaaS RATK and GaaS testing lab.

3.2.3 Non-functional Requirements

The non-functional requirements of the GaaS RATK include:

- The GaaS RATK supports several desktop and mobile platforms.
- The design of the GaaS RATK user interface abides by Apple Human Interface and Google's User Interface design guidelines whenever possible (Apple, 2016; Google, 2016).
- The device that runs the GaaS RATK has the ability to add a mini onboard LCD capacity touch panel connected to it, for testing and gaming purposes.
- The offered hardware device running the GaaS RATK offers a battery for portability purposes.
- The GaaS RATK runs on other single board microcomputers, which are not a part of the GaaS RATK offering.

- Any sensitive data collected remains private and anonymous, and is locked down with a modern password mechanism. Only authorized persons with the current authentication credentials can access the data.

3.3 System Architecture

The GaaS RATK was developed with Apache Cordova, AJAX, jQuery mobile, HTML5, PHP and Java. NWjs is used for the desktop version of the GaaS RATK. NWjs formally node.js is a rapid application development platform that allows HTML5, CSS and web integration scripts to run as a standalone multiplatform application that works on Windows, Linux and MacOSx. NWjs and Apache Cordova manage the unified Rapid Application Development (RAD) code base. The code base is unified and built off of a foundation of AJAX, jQuery, HTML5, PHP and JavaScript. All versions of the application (Android, iOS and the desktop versions) can be compiled from the same code base.

The chosen platforms respective IDE are used to build the unified code base. For Apple this is Xcode, for Android its Android Studio. Any push notifications code is centrally managed by Apache Cordova, with certificates and tokens being issued by the smartphone designer. Figure 11 represents a high-level view of how all of the GaaS RATK components work together. HTML 5 forms the building blocks of the graphical user interface, and this is how all of the components interact with each other. JQuery, JavaScript, Ajax and JSON encoded data is queried server side with scripting such as PHP to query the database for results, while also using them to insert data into and update the database. The development tools will also form the programmatic glue that helps develop the human usable functions of the GaaS RATK. AJAX and JSON allow the GaaS RATK to connect, enter and extract GaaS RATK information from the database securely over the internet.

Figure 10. **Toolkit High-Level Design**

Figure 10, represents the GaaS RATL High-Level Design. Any data entered is stored in a cloud based Maria DB database, which the Research Assessment Toolkit has a persistent connection to as long as it is connected to 3G, 4G or a wireless network. AJAX and PHP is the database connection bridge and injection tool. The backend server is a Linux server running Linux, Apache, MySQL and PHP. Open Source frameworks are used to keep costs down. Figure 11 represents the GaaS RATK component interaction. Several of the GaaS RATK components can interact with each other at once.

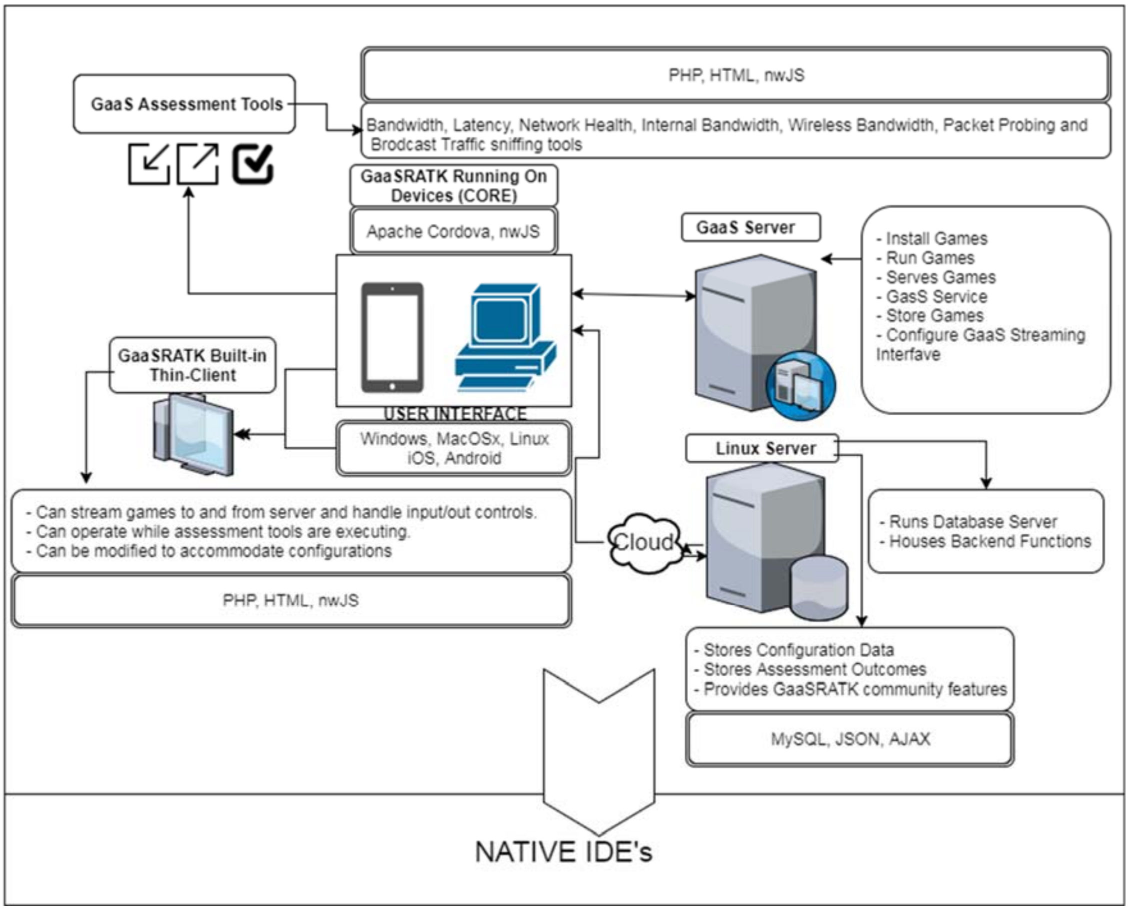


Figure 11. **GaaS RATK Component Interaction**

As a result this diagram breaks down how all the components interact with each other. Internally all actions originate from the GaaS RATK App, GaaS Server and the Linux server. These are the core components of the whole system. In this diagram, and for this experiment, we can see that most of the actions the GaaS RATK can perform can be triggered from GaaS RATK. For example, the user can initially perform assessment tests, query quick optimisation settings and also store test results based on their assessment tests if they so choose. It is possible for the user to launch the built-in client and immediately launch games to play to see what the result of the QoE will be. Figure 11 highlights that there are several actions happening simultaneously.

Client Components:

The Research Assessment Toolkit client (i.e., browser or mobile app) uses HTML5 as the centralized multi-platform container that stores the code base for all platforms. The code base then modularly extends to all platforms respective IDE's for build, compilation and API interactive extension. An AJAX call to PHP on the backend will processes all MariaDB connections and injection requests.

Server Components:

The server side components and framework use a command mode Linux server running PHP, AJAX and jQuery mobile reference libraries. AJAX and JSON are the connection bridge between front-end coding and back-end database calls. The Apache Web Server is used for severing all web content to the app, and MariaDB is the open source database of choice. Due to the funding and resource constraints for this project, a virtual machine is used to host the Linux server.

Client-Server Communication

The Research Assessment Toolkit client communicates to the backend Linux server using HTTP protocol over the internet. To reduce any extra internal load on the client, and for real-time sync purposes, the client communicates directly with the backend MariaDB database using AJAX and JSON. No information is actually stored in the client, except simple caching information to enhance load times of the front end client interface. The cache is cleared when the app is shutdown or reloaded. The only interface is HTTP and no caching information is sent back to the backend server. A private internal HTTPS certificate was considered, but due to time and resource constraints and the private distribution of the prototype app, HTTP is used for prototyping. If the app ever goes public after the research experiments, then HTTPS will be used for all database and session transfer connections.

4 CHAPTER IV – THE GAAS RESEARCH ASSESSMENT TOOLKIT

This section talks about the logistics of design and implementation of the GaaS RATK, in relation to its hardware, software and tools. Provided are screenshots and examples of the system being used in real world cases and situations, so as to highlight the GaaS RATK usages and workflow.

4.1 GaaS Research Assessment Toolkit - Hardware

The following is a breakdown of the affordable single board microcomputer that is complimentary to the GaaS RATK. The Standalone single board microcomputer comes pre-installed with the GaaS RATK. It is an all-in-one package and solution to provide researchers and players the means to optimize games and also test GaaS research and development. Although there are many single board embedded microcomputers on the market, a goal of the GaaS RATK was to make sure the GaaS RATK, had an open source, affordable, easy to use and compatible hardware offering to run on. It is the goal of the GaaS RATK, to contribute to the shortest path of optimization and testing of GaaS. Even if a user is experienced, they may not want to experience the frustration of wondering if the GaaS RATK software is fully compatible with the hardware and drivers. Of great importance is 3D acceleration and sound. In short, the user may just want the system to work out of the box, as a turnkey solution. The user is free to just try the GaaS RATK software on any platform they think is compatible, but in this scenario, with an open hardware offering, the user has an affordable, turnkey solution that has all drivers, components and system integration features working out of the box. An open hardware solution also provides the user with an easy modification and tinkering platform that is easy to reset if something goes wrong. An added addition of the GaaS RATK is that the user does not have to waste time doing extra research on random devices. In addition secondary to the hardware offering, the user has an out of the box lab testing environment that is affordable. Another added advantage is that the GaaS RATK does not affect a production machine that may contain other sensitive data, or competing software, therefore lessening the chance of software conflicts. All of these factors combined, constitute the GaaS RATK as a turnkey solution. The toolkit has the power to run the GaaS RATK, and also the Built in thin-client to test and play GaaS games. Table 1 breaks down the elements of the configured all-in-one toolkit.

Table 1 GaaS RATK Hardware

Component	Description
	Single board microcomputer: Samsung Exynos5422 Cortex A15 2Ghz Octa core CPU Mali T628 MPG (OpenGL ES and OpenCL Support) GPU 2GB LPDDR3 RAM eMMC 5.0 Flash Storage 2 USB 3,0 and 1 USB 2.0 port HDMI 1.4a OS: Linux GaaS RATK Installed Onboard Ethernet Port and Wireless Bluetooth On-board Sound
	Case Case to house single board embedded computer
	eMMC Memory Module Comes in 8, 16, 32 and 64 GB Sizes

	Multitouch 1024 x 600 LCD Screen An optional LCD Screen for compact testing

The GaaS RATK is directly integrated into the single board microcomputer for ease of use. It was important that the GaaS RATK was an all in one solution for testing and possible improvement of the QoE with GaaS. The inclusion of integrated and affordable hardware ensures that the user has a functional out of the box experience with the GaaS RATK.

The hardware operates in several configurations. The two dominant modes are table top mode hooked to a monitor and table top mode hooked to portable.

For a more seamless gaming experience, the hardware supports specific controllers (see Figure 12). Standard keyboard and mouse are supported too. No lockouts of the hardware exist and if the user so chooses, they can modify the system in a way that works for them, and their research.

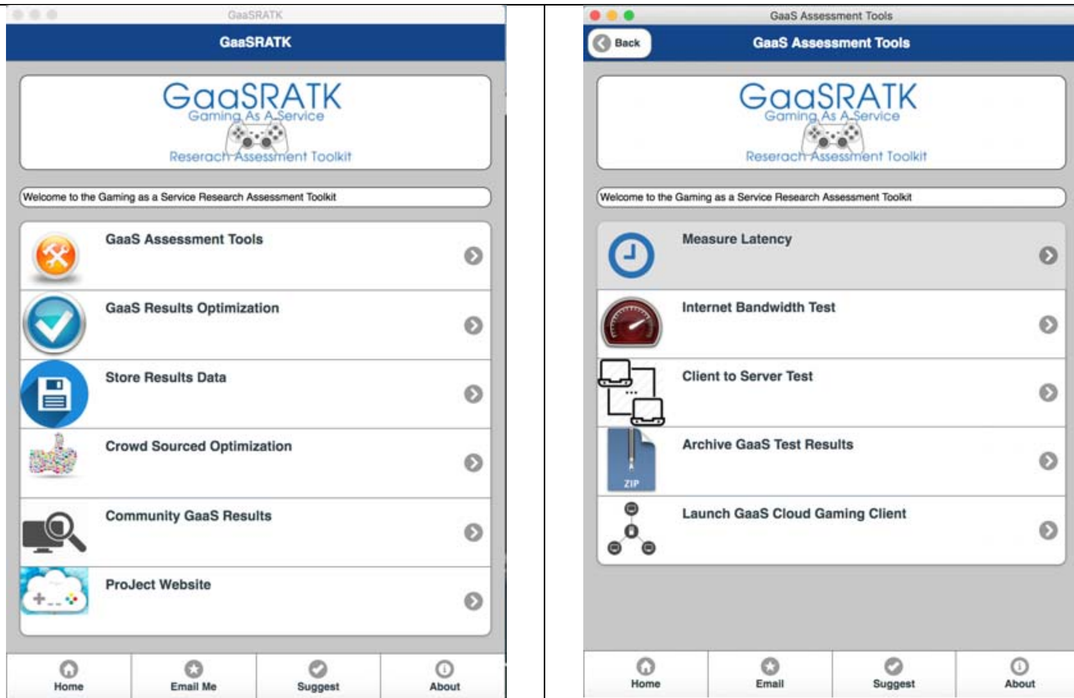
Figure 12. **GaaS RATK Game Controllers**

4.2 GaaS RATK Software – The Application

It should be noted that the GaaS RATK is standalone, and the installation is fully automated, including the installation of all dependencies. The auto installation script is kick-started from the GUI once the initial download of the GaaS RATK occurs. This is true for all desktop platforms that the GaaS RATK runs on (MacOSx, Linux and Windows).

4.2.1 The GaaS RATK Tools

The GaaS RATK consists of the following functions and features. The main menu (see Figure 13) is the hub or starting point from which all functions can be run. From the main menu a user can run the assessment tools, results optimization, store results data, crowd source an optimization, search the community results and visit the GaaS RATK project website (see Figure 13).

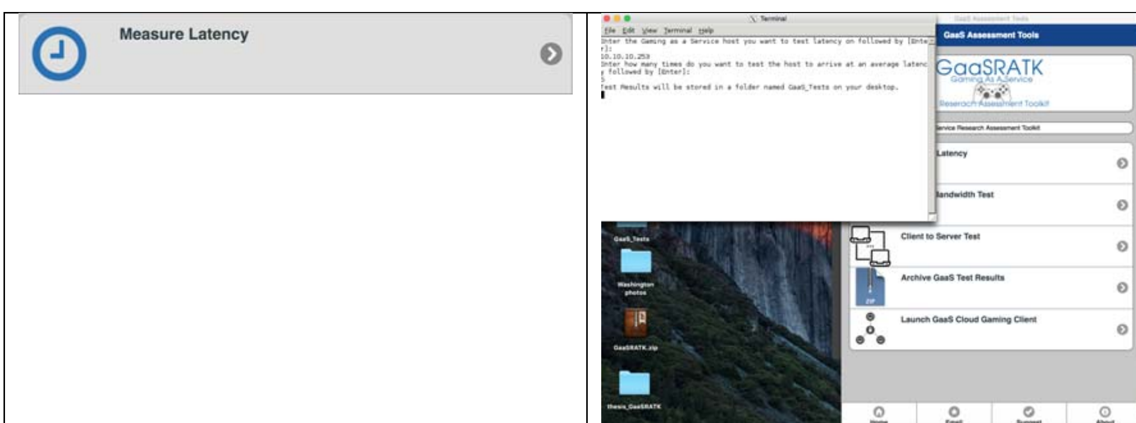


(a)	(b)

Figure 13. **GaaS RATK Main Menu and Assessment Menu**

4.2.1.1 *The GaaS RATK Latency Measurement Test*

From the assessment tools screen, we can measure for latency. We can enter the IP address or domain name of the GaaS server to measure latency as Figure 14 shows.



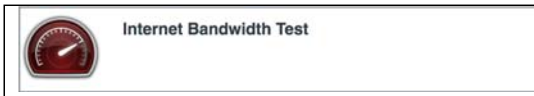
Measure Latency	Actually latency test being performed

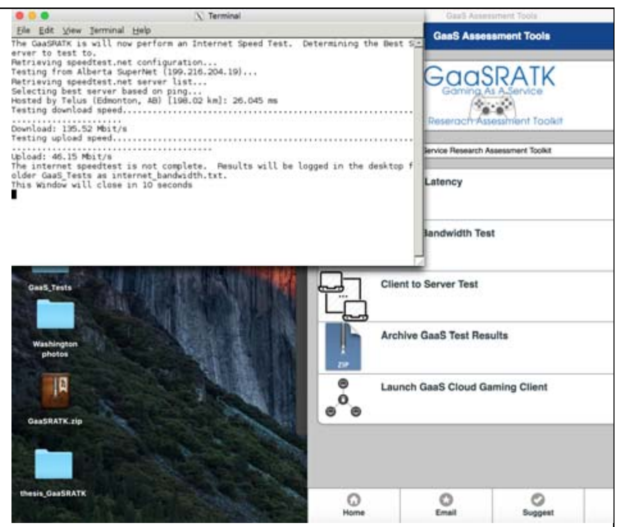
Figure 14 **Latency testing within the GaaS RATK**

The latency function also allows users to set the cycles or times they want to test the GaaS Server. Once the amount of cycles are determined by them, the GaaS RATK carries out the latency test and then exports the tests for the user to view when it's finished. All tests are stored in a special folder on the device that the GaaS RATK is installed on. The folder can be referenced at any time by the user to review any or all of the tests.

4.2.1.2 The GaaS RATK Internet Bandwidth Test

The GaaS RATK can also perform an accurate bandwidth test to the clearest path or node on the Internet, from the device that the GaaS RATK is installed on. The bandwidth test is fully automated. No special 3rd party plugins or software is needed. Every test within the GaaS RATK is self-sufficient once the initial auto-configuration and installation occurs. Figure 15 shows this function running in real-time.





Internet Bandwidth Test	The internet bandwidth test running in real-time

***Figure 15.* The GaaS RATK Bandwidth test**

4.2.1.3 The GaaS RATK Client to Server (Node-to-Node) Test

Aside from an internet bandwidth test, the GaaS RATK has the ability to run a node-to-node client to server direct test. Both nodes can exist on the same Local Area Network (LAN), or even two networks remotely to each other, as long as the port for a basic test is open. There is a default port preconfigured for the users.

This function has two simple requirements. The node-to-node test requires the user to start the listener on the remote or local GaaS Server, and then kick off the test from the GaaS RATK GUI. Since this is a node-to-node test, it provides more realistic results of what bottlenecks the GaaS client may encounter, as data travels to the server, and back again from the server to the client. This test (see Figure 16) will help to determine the health of internal and external networks that GaaS Data will be traversing, and allows the users the opportunity to see if they can rectify any of the alleged issues that may exist.

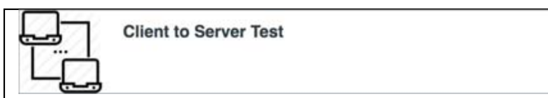
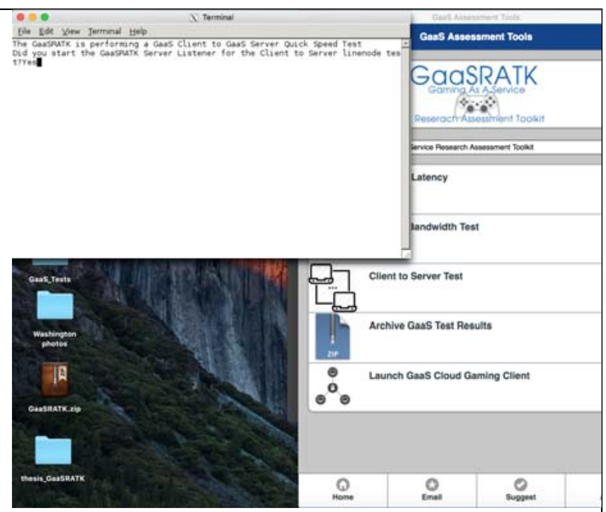
	
Client to Server test	Real-time exmaple of the Client to server test

Figure 16. **The GaaS RATK Client to Server Test**

4.2.1.4 GaaS RATK Cloud Archival Function

Aside from the standard assessment testing, the users can also choose to archive all test results to Google, as well as reset the testing folder as Figure 17 shows. If the users choose the archive GaaS Test Results function, the GaaS RATK will automatically compress all of the test results and upload them to a chosen Google Drive. It should also be noted that to start a fresh batch of tests for later archival and review, the users can choose to reset the GaaS_Tests folder at any time of their choosing, for a new round of research or optimization.

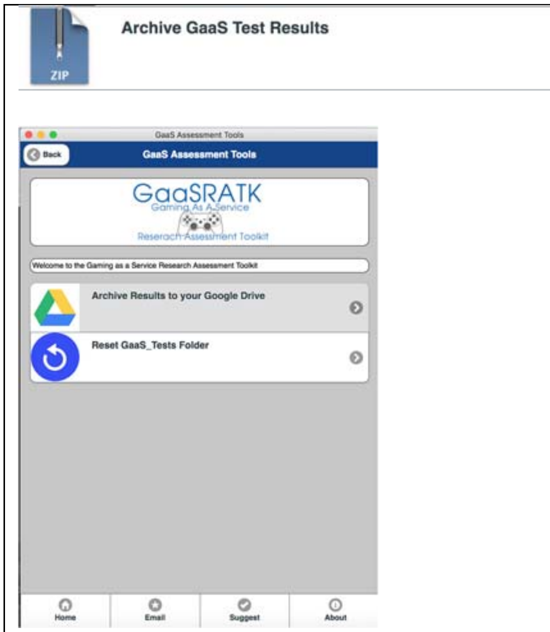
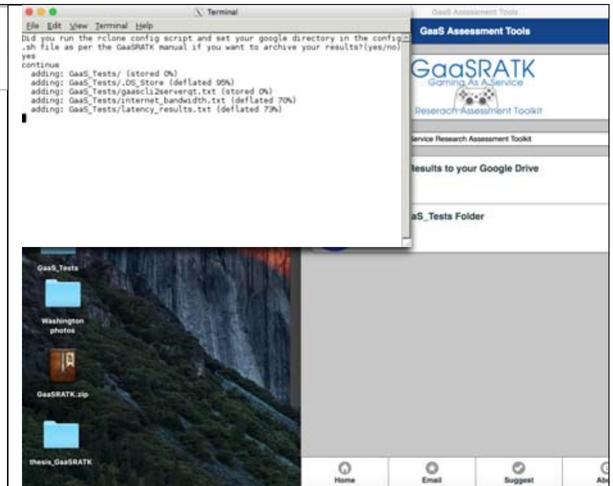
	
Archive GaaS Test Results, and reset testing folders	Reset the GaaS test folders

Figure 17. **The GaaS RATK Cloud Archival Function**

4.2.1.5 The GaaS RATK Thin-Client

The GaaS RATK has a built-in thin-client that is able to connect to GaaS Servers and play the games that are installed on it. The thin-client is also compatible with numerous game controllers (wired and wireless), and also supports keyboard and mouse functionality. Sound is also fully emulated through the thin-client. The thin-client allows the users to input several different max bitrate numbers, resolution and FPS so as to test the best QoE with the suggested or discovered configuration settings. Since the thin-client is fully integrated into the GaaS RATK, the users' focus can remain on the evaluation of their GaaS research without leaving to gather multiple external toolsets to optimize their research and QoE (see Figure 18).

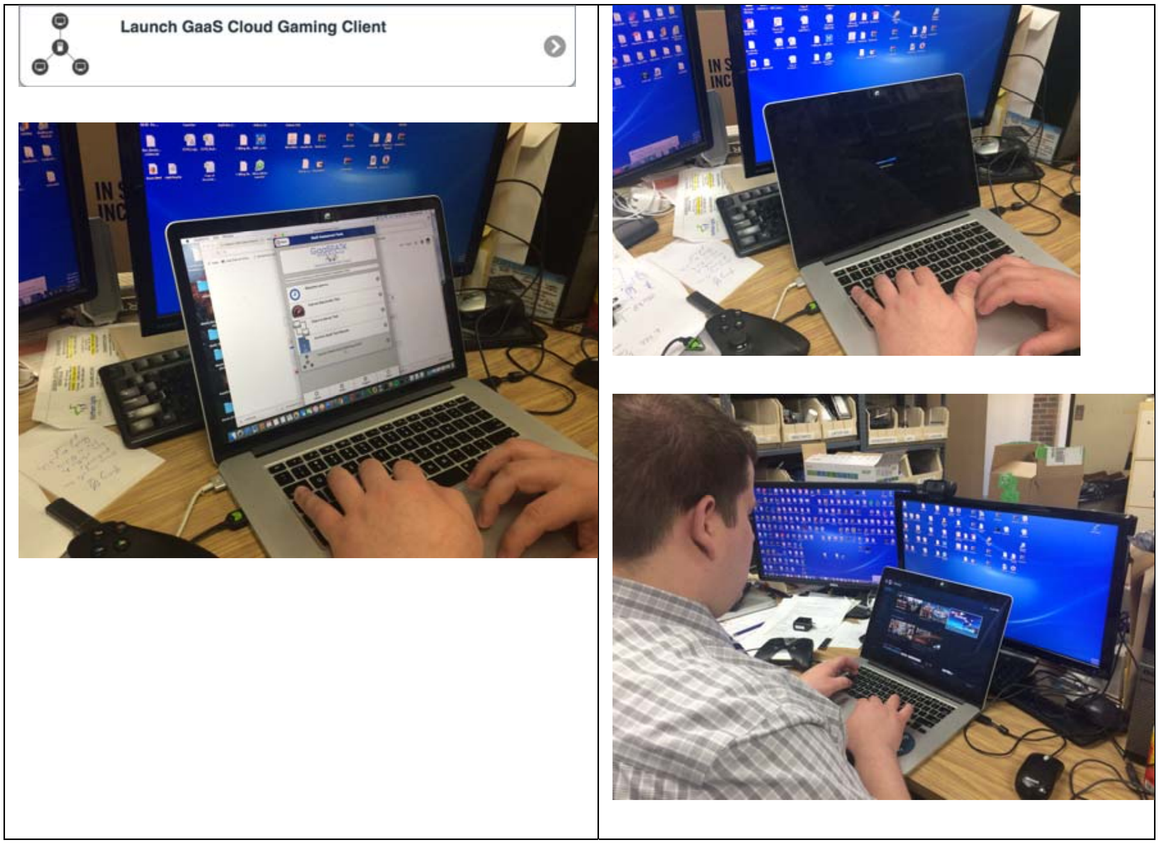


Figure 18. **A user launches the GaaS RATK to test the assessment settings**

4.2.1.6 Optimized Settings & Crowdsourcing

With the optimized settings and crowdsourcing functions users can use the assessment tools results and enter their data in, to quickly optimize their settings. The system will do its best to provide a match, and suggest some settings that may work to quickly optimize the users' GaaS experience, as Figure 19 shows. The user may also enter configuration data into the GaaS RATK database, which can later be queried and then voted on by other people who use the GaaS RATK as Figure 20 shows. Once configurations are voted on, any configuration that gets 10 or more votes will be automatically certified as working within the configuration parameters. This feature is another way the users can quickly optimize their GaaS Experience.

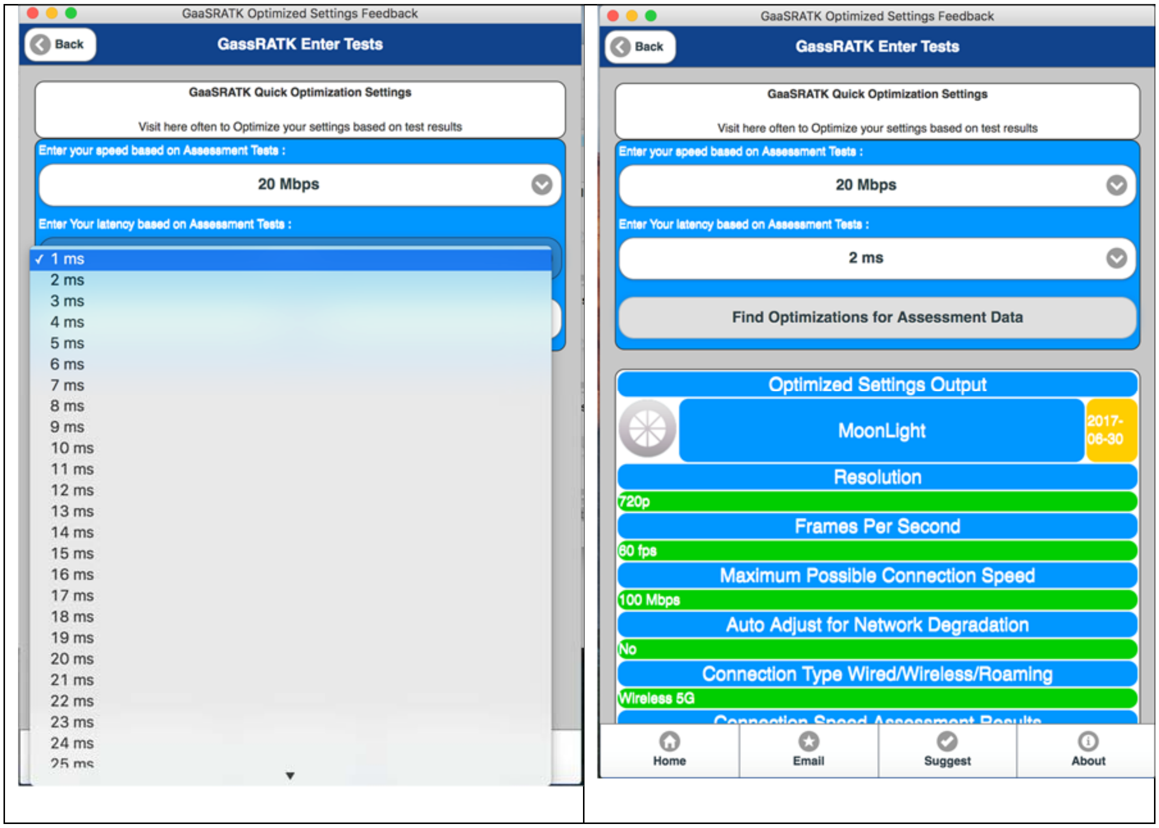


Figure 19.**The GaaS RATK quick optimization screen**

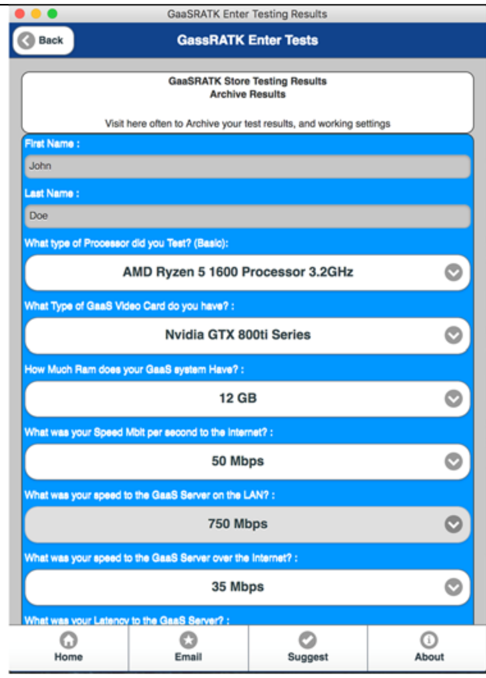


Figure 20. **Configuration and test results data being entered into the GaaS RATK**

4.3 GaaS RATK Real World Use Cases

Below are the intended real world user case scenarios for the GaaS RATK. Presented are several possible usage case scenarios.

4.3.1 Use Case Scenarios

4.3.1.1 User Case Scenario #1 – Static Feedback Optimization of GaaS

Figure 21 presents the user case's workflow and Figure 22 show how the GaaS RATK works in a real-world scenario.

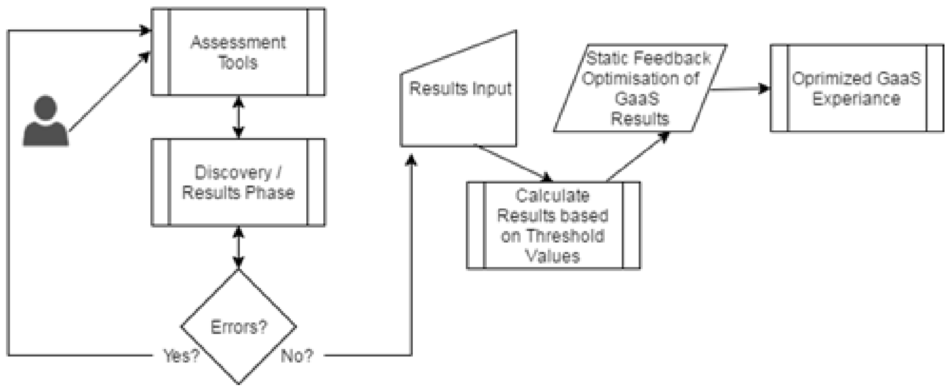


***Figure 21*. Use Case Scenario #1 – Static Feedback Optimization of GaaS**

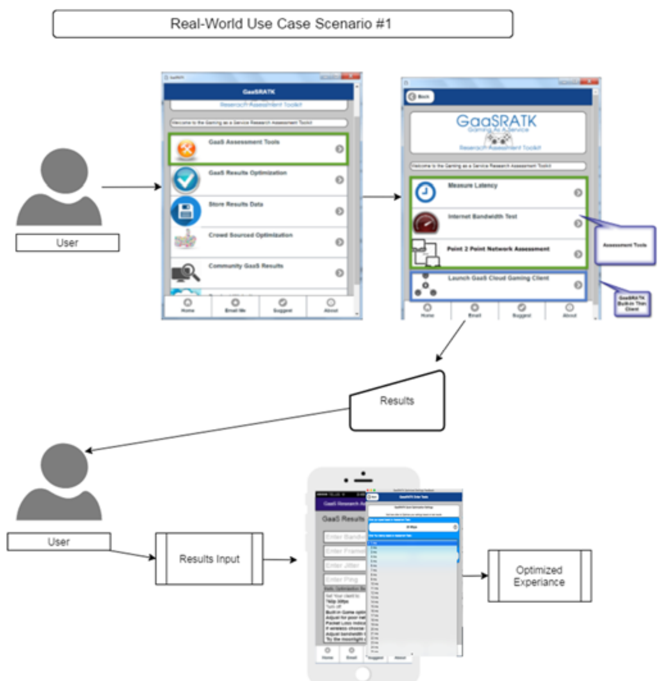


***Figure 22*. Static Feedback Optimization of GaaS**

The user is presented with the GaaS RATK main menu. He or she can choose the assessment tools menu, which consists of all assessment tools and the built-in thin-client. The user can then run the assessment tools to acquire a GaaS baseline for his or her GaaS system. The results are dumped to the desktop but the user can also choose to automatically compress them in to a zip file for archival by date and send the results to google drive. If errors occur, the test can be re-run. The user can then apply the results to the "Assessment Feedback Optimization" menu to see if there are some "best case scenario" results that could optimize his or her GaaS gaming experience. The GaaS RATK will attempt to query known good results or configurations, and suggest a configuration to the user. The user can test the configuration on the built-in GaaS RATK client. He or she can also experiment with variations of the configuration within the client to find the best optimization settings for the game they are streaming.

4.3.1.2 Use Case Scenario #2 – Research Assessment Archival & Optimized Settings Discovery

In this use case scenario, a researcher can run baseline results against their own GaaS research, and or GaaS enhancement, and see if the research has yielded any improvements. If we reference Figure 23, we can see there are 2 stages to this workflow and real-world case scenario.

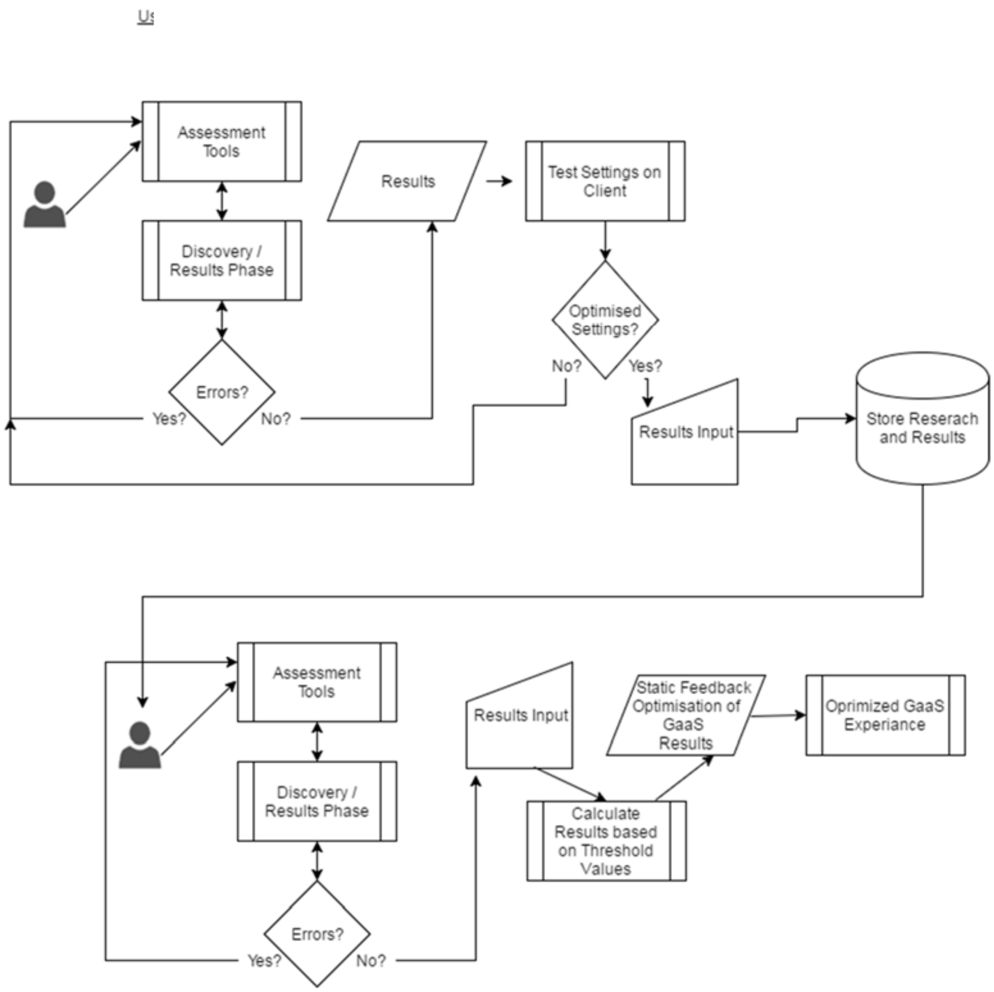


Figure 23**. Scenario #2 – Research Assessment and Archival – Optimized Settings Discovery**

The two stages involve the researcher and possibly the user or the gamer. The researcher from the main menu chooses the assessment tools menu. The researcher runs the assessment tools, and establishes a baseline for the GaaS System, the research optimization, and the network. At this point the researcher decides if the GaaS research optimization was successful based on the results and testing within the built-in GaaS RATK client. If the research optimization was unsuccessful, the researcher updates their project and runs the tests again until the desired results are obtained. The researcher(s) then enter the GaaS optimization results and configurations into the global GaaS RATK repository for future reference by other researchers and users. At this point, as suggested by the Figure

24, other researchers and users can access this configuration and test results data to see if it can optimize their play experience or research.

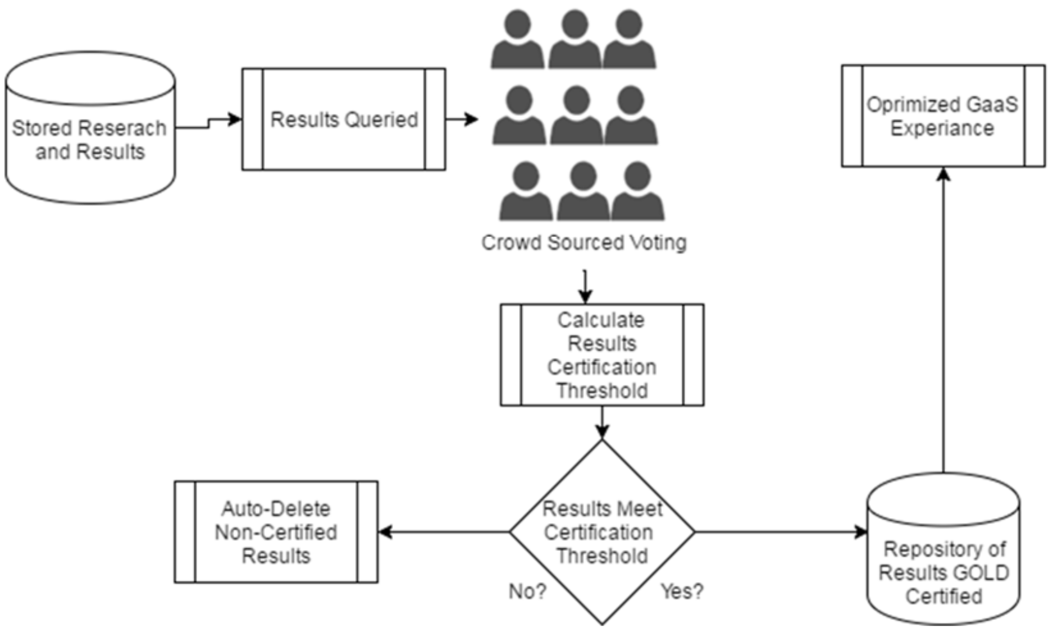


***Figure 24. Use Case Scenario #3* – Crowd Sourced Certification of Static Feedback Optimization**

In this scenario, the repository of research results within the GaaS RATK really starts to come into fruition. In Figure 24, the workflow and real-world case scenario for crowd sourced certified results is explained. The internet and GaaS RATK community can read-only query the global GaaS RATK data repository. Once a query is obtained that is favorable to a community members GaaS System configuration and capability, the user can test it. The community member(s) can then vote on the queried configuration if it optimized their GaaS experience. If the queried configuration gets enough up votes to reach the certification threshold, then the configuration is certified as optimized. Non-working configuration votes can affect the certification threshold and un-certify a configuration if it becomes unreliable over time. In this scenario configurations are naturally certified and uncertified using the power of crowd sourcing.

4.4 Research Assessment Toolkit – Real World Demonstration

Please find below a real word demonstration of the GaaS RATK. This user is a gamer, and wanted a quick path to optimize his QoE for a GaaS System. The user was not pleased with a vanilla GaaS system QoE, and chose to see if the experience could be enhanced using the assessment feedback optimization feature in the GaaS RATK. In this particular case, the user noted how important it was to quickly get back to the game, and also wanted the chance to immediately improve his QoE once initial base line assessment testing was finished.

4.4.1 Real World Demonstration – Assessment Feedback Optimization

In figure 25, the gamer starts with assessment testing. The gamer runs latency, internet bandwidth and a client to server (node-to-node test). Although the gamer could have used the complimentary hardware kit for the GaaS RATK, since the GaaS RATK is multiplatform, the gamer chose to run the software on his Mac computer.

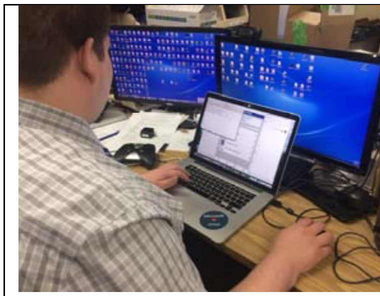
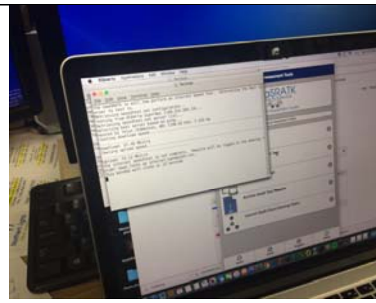
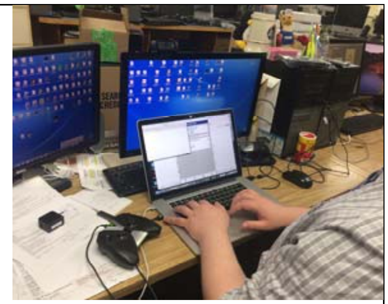
		
The gamer performs a Client to Server node-to-node test	The gamer performs a Internet bandwith test	The gamer performs a latency test

Figure 25. **The User Preforms Several Real World functions in the GaaS RATK**

After the gamer performs assessment testing, the results of the assessment tests, are reviewed. The gamer then if they want decides to run the tests several times to get a mean and standard baseline for the system. All tests are appended to the current ongoing batch of tests for review. After the gamer is satisfied with the assessment tests, he moves on to the assessment feedback optimization function of the app. After reviewing the results, in Figure 26 the gamer decides to import some specific settings into the assessment feedback optimization screen, to see if they can query some configurations that may improve the gaming experience with GaaS and the current game.

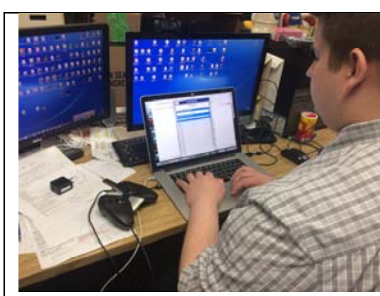
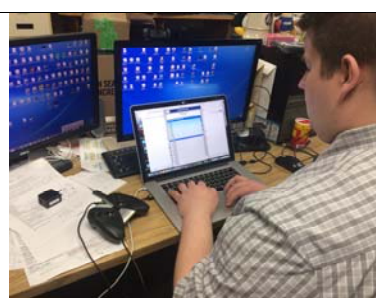
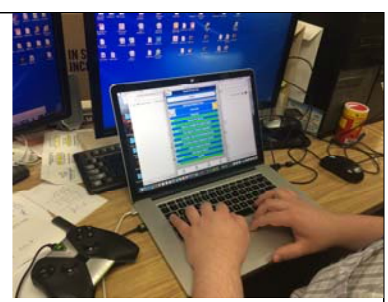
		
The gamer enters the Assessment Feedback Optimization screen of the GaaS RATK	The gamer inputs the important parts of his assessment results in the assessment feedback screen	The GaaS RATK returns possible optimized settings for his GaaS System

Figure 26. **A User optimizing the settings of a GaaS System with the GaaS RATK**

In figure 27, the gamer decides to launch the GaaS RATK built in thin-client to test the configurations and optimizations that the GaaS RATK has provided. It should be noted that the gamer can not only enter configuration settings received from the GaaS RATK, but the gamer can also change values on the fly in the GaaS RATK thin-client to tweak the GaaS experience further.

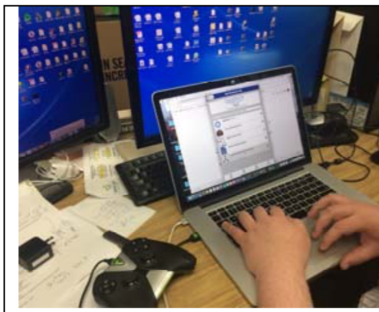
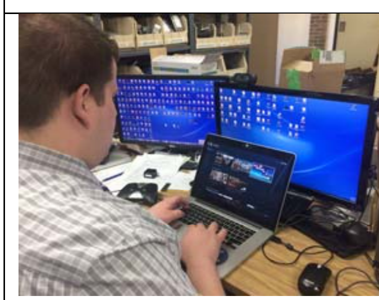
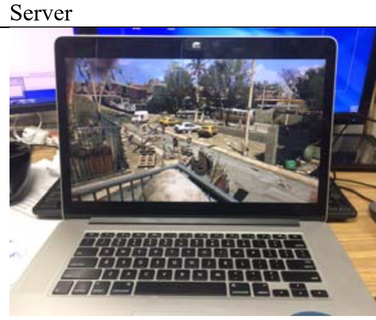
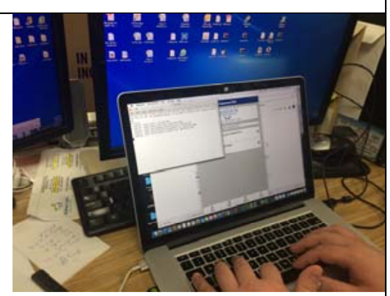
		
The gamer launches the GaaS RATK thin-client and is prompted for his configuration settings	The GaaS RATK thin-client performs a handshake with the server and loads the remote GaaS Server	The videogames on the GaaS Server are loaded
		
The gamer launches the game with the optimized settings	The gamer plays the game to see if the gaming experience has improved	The GaaS RATK is used to compress and upload the testing data to the cloud

Figure 27. **GaaS RATK and built in thin-client are used to apply optimized settings**

After the built in thin-client connects to the GaaS Server, the gamer runs the game with the optimized configuration and tests it for any anomalies. The gamer plays the game to ensure the gaming experience has improved. If the gamer is satisfied with the current cycle of results, the gamer can use the GaaS RATK to automatically compress the results for this testing and assessment cycle and upload them to the cloud for future reference and usage.

5 CHAPTER V – EVALUATION AND DISCUSSION

This chapter focuses on an experiment to discover the user perception and attitude toward the GaaS RATK. The researcher evaluated the perceived ease of use and whether its options, feature sets and components created a GaaS experience that provides the shortest path to optimization for the users and makes them willing to use the toolkit.

This chapter first introduces the research model and hypotheses that were invoked by the literature review and its suppositions. Section 5.1 explores the evaluation plan and explains the research questions for this experiment. Following this, the research model and hypotheses are presented. This section also talks about the questionnaire design based on the Computer Game Attitude Scale (CGAS), the Technology Acceptance Model (TAM) and the System Usability Scale (SUS) and the methodology that was used for participant recruitment and data collection. Section 5.2 explores some of the data collected from the questionnaire and verifies its reliability and validity. Section 5.3 presents the data analysis and results. Lastly Section 5.4 reveals and discusses the common and important findings of the experiment.

5.1 Evaluation Plan

Lala (2014) suggests that the Technology Acceptance Model (TAM) would be useful in relation to this research. TAM indicates that perceived usefulness and ease of use equate to a person’s intention to actually utilize a system, which is suggested to be a bridge to real world usage. Ajzen and Fishbein (1977) relate TAM is synthesized from the Theory of Reasoned Action (TRA) a foundation of belief, attitude and intention. Based on TAM, a series of research questions were formulated. These research questions were then used to later synthesize the hypotheses and questionnaire. The following twenty questions were formulated based on the TAM research.

(1) Do users find the proposed GaaS RATK app useful?

(2) Do users find the proposed GaaS RATK app accurate?

(3) Is the proposed GaaS RATK app perceived as useful by users?

(4) Is the proposed GaaS RATK app perceived as easy to use?

(5) Does the proposed GaaS RATK app encourage a user to continue using GaaS systems? (Motivation)

(6) Does the user's perception of gaming and attitude influence his/her attitude in regards to using the GaaS RATK?

(7) Does gender play a role in regards to a user's attitude or behavioral intention of using the GaaS RATK?

(8) Does the users' gaming experience seem to have an effect on his/her attitude and acceptance in regards to utilizing the GaaS RATK?

(9) Does the user's gaming experience (hardcore or casual) play a role in influencing behavioral intention of using the GaaS RATK?

(10) Does the users willingness to use the GaaS RATK, influence their attitude and behavioral intention of using the GaaS RATK?

(11) Do users find the proposed GaaS RATK app useful?

(12) Do users find the proposed GaaS RATK app accurate?

(13) Is the proposed GaaS RATK app perceived as useful by users?

(14) Is the proposed GaaS RATK app perceived as easy to use?

(15) Does the proposed GaaS RATK app encourage a user to continue using GaaS systems? (Motivation)

(16) Does the user's perception of gaming and attitude influence his/her attitude in regards to using the GaaS RATK?

(17) Does gender play a role in regards to a user's attitude or behavioral intention of using the GaaS RATK?

(18) Does the user's gaming experience seem to have an effect and his/her attitude and acceptance in regards to utilizing the GaaS RATK?

(19) Does the user's video game experience play a role in influencing behavioral intention of using the GaaS RATK?

(20) Does the users willingness to use the GaaS RATK, influence their attitude and behavioral intention of using the GaaS RATK?

5.1.1 Research Model and Hypothesis

The usability of a system is considered to be of the upmost importance when taking into consideration the design and development cycle. Pavapootanont & Prompoon (2015) defined a usability quality metric for mobile game prototyping which included the following attributes of understandability, learnability, operability attractiveness and compliance. Hussain & Ferneley (2008) analyzed existing measurement models related to usability, which led to the proposal of a new set of guidelines for mobile and device application development. It is my belief that the proposed GaaS RATK is the first of its kind. As a result of this, TAM may not fully reflect the influences between the GaaS RATK app used to improve and assess the GaaS experience, and the user's acceptance. A user's general attitude and acceptance in regards to gaming and GaaS may also be a factor that impacts their attitude toward using the GaaS RATK.

In consideration of these factors the research model also uses the Computer Game Attitude Scale (CGAS). Chappell and Taylor (1997) first conceived and introduced the CGAS. The CGAS has been proven to have reliability and validly in regards to measuring attitudes. The first CGAS consisted of twenty items for testing two main subscales which are comfort and liking. To expand on attitudes toward gaming, among genders and younger children for example, revised versions of the CGAS were conceived. Chang, Kuo, Zhi, and Liu (2014) conceived a revised CGAS scale based on four factors (confidence, learning, liking and leisure), and three subscales (cognition, affection and behavior). The CGAS can be used to measure the attitudes of children as young as seven, and can also gauge the attitude differences among gender, preferred way of gaming and game play experience. The legacy CGAS and recent CGAS revision were taken into account when the research model and hypotheses were designed. The result is a CGAS that produced a questionnaire that has strong reliability and validity, and is covered in the next section. Figures 28 and 29 shows a visualized research model in micro and macro view respectively.

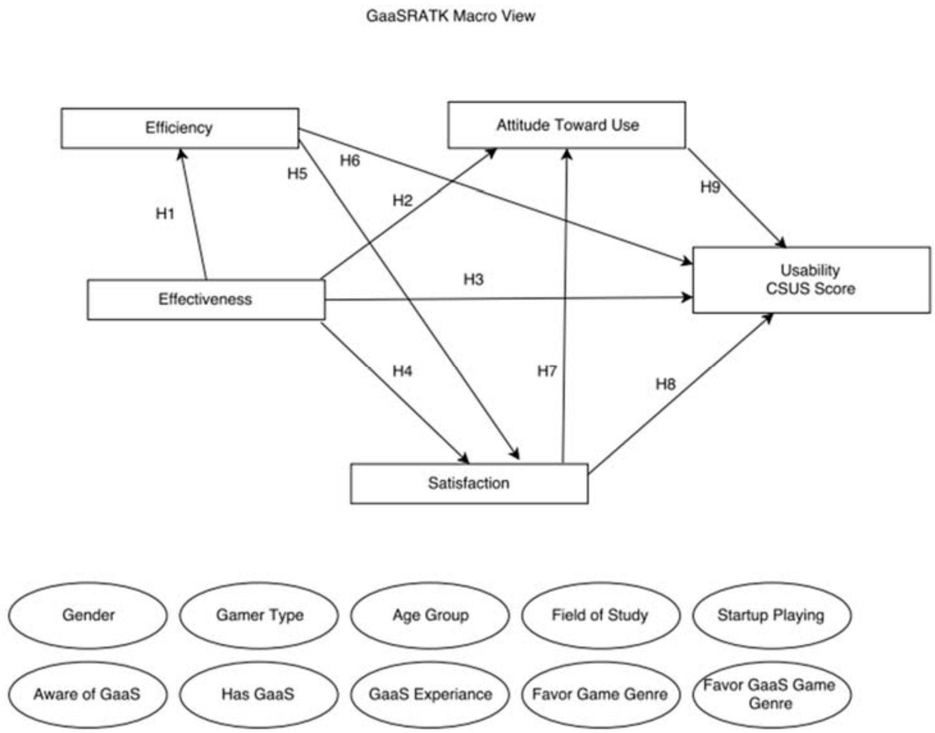


Figure 28. **Macro view of the GaaS RATK research model**

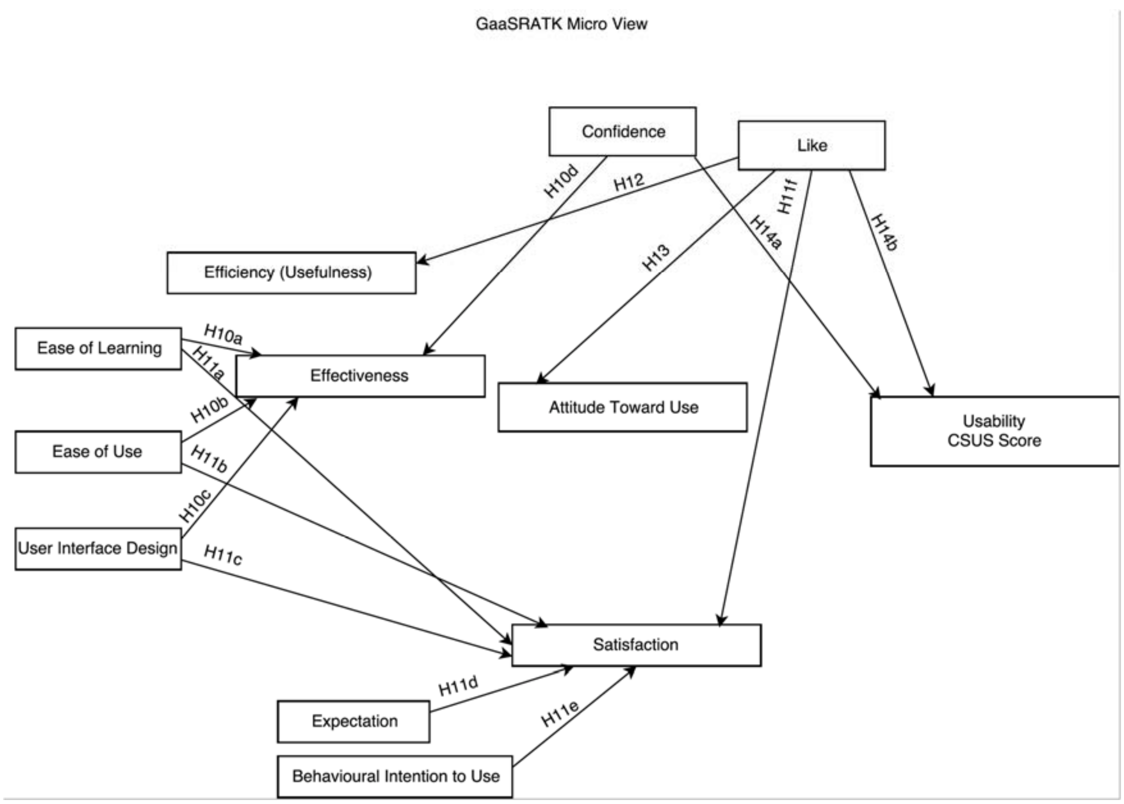


Figure 29. **Micro view of the GaaS RATK research model**

Table 2 explains all Operational Construct Definitions.

Table 2 Operational Construct Definitions

Attitude Toward Use	Assesses a participant's attitude toward using the GaaS RATK by asking a series of specific questions, about a user's perception and attitude towards the system. Derived from TAM (the technology assessment model and USE questionnaires.
Behavioral Intention to Use	Assesses if the user will use the system again, repeatedly or in the future. Derived from SUS, TAM and Usability Questionnaire methodology.
Confidence	Assesses a participant's confidence with playing video games and or computer games. Is a part of the computer games Attitude Scale (CGAS).
Easy of Learning	Assesses how easy a participant was able to learn and operate a system such as the GaaS RATK. derived from the System Usability Scale (SUS), TAM and USE. .
Ease Of Use	Assesses how easy it is for the user to operate or use a system such as the GaaS RATK. Derivied from SUS.
Effectiveness	Assesses the perception of the user of a system such as the GaaS RATK, to see if the user perceives the system as effective. Derived from SUS, TAM, USE, Usability and CSUQ (the Computer System Usability Questionnaire [Scale]).
Efficiency	Assesses the user's perception about how efficient they feel a system such as the GaaS RATK is at performing its intended tasks, and providing information that cues the user on how to perform information tasks. Derived from CSUQ, USE and TAM.
Expectation	Assesses the user's expectation of the GaaS RATK, and if those expectations were achieved. Derived from CSUQ, TAM and USE.
Like	Assesses how much a participant likes video games, and to what degree. A part of the CGAS.
Satisfaction	Assesses how satisfied a participant is with the GaaS RATK, and if they will continue to use it and recommend it to others. Derived from SUS, TAM, Usability, CSUQ and USE.
Usability (SUS Score)	Assesses how usable the GaaS RATK is, by scoring how usable the user felt it was. The higher the score the more usable the user felt it was.
User Interface Design	Assesses the user interface design of the GaaS RATK. IE: Was it pleasing, confusing, easy to use, easy to navigate, visually appealing etc. Derived from CSUQ, Usability and USE.

Some assumed relationships occur in the macro and micro research models above (M. Chang et al., 2014). In regards to TAM (Huang & Chen, 2016), Table 3 integrates the core features of TAM (perceived usefulness, perceived ease of use, attitude toward using, behavioral intention to use and actual system use) into the hypotheses. Table 3 represents all the Macro View Hypothesis.

Table 3. Hypotheses Macro View

Hypothesis #	Macro View Hypothesis
H1	Perceived Effectiveness of the GaaS RATK will have a relation to Efficiency
H2	Perceived effectiveness of the GaaS RATK will have a relation to Attitude Toward Use.
H3	Effectiveness of the GaaS RATK will be related to Usability.
H4	Effectiveness of the GaaS RATK will be related to Satisfaction.
H5	Perceived Efficiency of the GaaS RATK will be related to Satisfaction.
H6	Perceived Efficiency of the GaaS RATK will be related to Usability.
H7	Perceived Satisfaction of the GaaS RATK will be related to Attitude Toward Use.
H8	Perceived Satisfaction of the GaaS RATK will be related to Usability.
H9	Attitude Toward Use of the GaaS RATK will be related to Usability.

For the next set of hypotheses as Table 4 lists, CGAS, SUS and perceived Usability were integrated to fully flush out the collected data. Although the constructs of CGAS 1997 were taken into full account as a part of the hypotheses, it should be noted, that the more updated CGAS 2014 from Chang et al. (2014), was applied and utilized for the hypotheses. Factors included were confidence and liking, since the proposed research has video games as a core element. The original Hypothesis statements were constructed from the known good hypothesis and questionnaire data that was authored by (M. H. Chang et al., 2018).

Table 4. Hypothesis Micro View

Hypothesis #	Micro View Hypothesis
H10a	Perceived Ease of Learning of the GaaS RATK will be related to Effectiveness.
H10b	Perceived Ease of Use of the GaaS RATK will be related to Effectiveness.
H10c	H10c: The User Interface Design of the GaaS RATK will be related to Effectiveness.
H10d	A participants Confidence in the GaaS RATK will be related to its Effectiveness.
H11a	Ease of Learning of the GaaS RATK will be related to satisfaction.
H11b	Ease of Use of the GaaS RATK will be related to satisfaction.
H11c	The User Interface Design of the GaaS RATK will be related to Satisfaction.
H11d	The participants Expectation of the GaaS RATK will be related to Satisfaction.
H11e	A Participant’s behavioral Intention to Use the GaaS RATK, will be related to Satisfaction.
H11f	How much a participant Likes Video Games, will be related to GaaS RATK Satisfaction.
H12	To the Degree a participant Likes Video Games will be related to their perception of the GaaS RATK’s Efficiency and Usefulness.
H13	To the Degree a participant Likes Video Games will be related to their Attitude Toward Use of the GaaS RATK.
H14a	The participants Confidence with playing Video Games will be related to their perceived Usability of the GaaS RATK.

H15b	How much a Participant Likes Video Games will be related to their perceived Usability of the GaaS RATK.

In regards to explaining the relationships between the scales and constructs that are used in this thesis research model, and the hypothesis, it is important to start with good known research by authors such as (M. Chang et al., 2014) who performed detailed work and revision of the CGAS. As part of this explanation we also need to acknowledge the known good research work of (Lala, 2014), in regards to TAM. Also included in this explanation is the work of (Brooke, 1996) and (Brooke, 2013), whose work on SUS helped evolve the research model in this thesis. The work of the aforementioned authors, helped evolve the research model in this thesis. One has to use proven scales and constructs to develop a working research model that is referenced and constructed from known good methods.

Drawing on former research, the research models and constructs were put into place, using proven methodology. To keep the research model valid and reliable, built in relationships to the constructs and factors were utilized. For example Ease of Use, Ease of Learning and User Interface Design, could determine Effectiveness, based on previous research into scales and research models. As a result we draw a relationship between the Hi level factors and their contributing factors. Another example is Behavioral intention to use and expectation which could determine Satisfaction. We also draw relationships between the Hi-level and contributing factors. Moving in a circle clockwise one endeavors to draw the possible relationships between all factors. We cannot forget the CGAS, since it is one of our scales, and we also draw arrows to signify the relationships that could occur between these scales, and all the other factors. Lastly, we know that all of these scales are ultimately contributing to System Usability and or Usefulness, so we make sure all factors point back to Usability. The research models are a great visual representation, of what our hypothesis could be, so we try to visually map and number our hypotheses within the research model, to help us write possible hypothesis based on our new visual relationship. When this task is complete, there is a solid visual representation that can help contribute to the hypothesis statements. This is how the research models are related to the hypothesis.

The following moderator research questions in Table 5 were created for the experiment. It was felt that these questions and their answers were important and would have an effect on the experiment as well as provide insight into the GaaS RATK, and its significance to its users.

Table 5. GaaS RATK Macro View Moderator Research Questions

Moderator #	Moderator Research Question
1	Does gender affect a user's perceived Effectiveness toward the GaaS RATK?
2	Does gender affect a user's perceived Satisfaction toward the GaaS RATK?
3	Does gender affect a user's perceived Efficiency toward the GaaS RATK?
4	Does gender affect a user's Attitude Toward Use of the GaaS RATK
5	Does a participants Field of Study affect one's Attitude Toward Use of the GaaS RATK?
6	Does a participant's Field of Study affect one's perceived effectiveness toward the GaaS RATK?
7	Does the participant's Field of Study affect one's perceived efficiency of the GaaS RATK?

8	Does the participant’s Field of Study affect one’s perceived satisfaction of the GaaS RATK?
9	Does the gamer type (Hardcore vs. Casual) affect one’s perceived Effectiveness toward the GaaS RATK?
10	Does the gamer type affect one’s perceived efficiency toward the GaaS RATK?
11	Does the gamer type affect one’s Attitude Toward Use of the GaaS RATK?
12	Does gender affect one’s chosen field of study?

5.1.2 Questionnaire Design

A reliable questionnaire was designed based on CGAS, TAM, SUS and Usability factors. The questionnaire is unique to the proposed thesis and is modeled after known good methods for data collection for reliability and validity. Liu, Lee, and Chen (2013) developed a new computer game attitude scale for Taiwanese early adolescents that provides a good CGAS questionnaire model. The CGAS 2011 questionnaire provides a good model for computer game attitudes among youth, and its validity and reliability were tested with the collected data from 354 elementary school students. The CGAS 2011 was refined to use the Likert scale to assist the students in selecting a thoughtful response to the questionnaire, instead of a natural response without thinking. The final CGAS 2011 questionnaire includes 22 items for three subscales and five factors. The items provide a great model to start developing a reliable and valid questionnaire to collect data.

Although the CGAS 2011 provides a great model for adaption, it should be noted that although gender is addressed, grade or learning level, preferred gaming way and game play experience are not included. Chang et al. (2014) propose a CGAS 2014 model that address these missing items, and as a result, also provides a great model for CGAS questionnaire adaption. The CGAS questionnaire used in this research is based on Liu et al. (2013) and Chang et al. (2014)'s CGAS questionnaires.

It is stated by Park (2009), that the TAM can account for 40 to 50 percent of technology acceptance. It is also stated by Venkatesh, Davis, & College (2000), that revised versions of TAM, such as TAM2, can account for up to 60 percent of user acceptance and or adoption. Lee, Cheung, and Chen (2005), suggest that a TAM reliability rate above 0.50 is deemed acceptable. They also show that newer TAM models can reach a composite reliability rate of .75 to .90. It becomes clear that when usability is factored in, that the questionnaire would benefit greatly from TAM. As a result TAM was integrated into the questionnaire for this research, with all related items utilizing the Likert-scale (5 for ``strongly agree`` to 1 for ``strongly disagree``) to address the known constructs of the TAM Model –perceived usefulness, perceived ease of use, attitude toward using, and behavioral intention.

It became clear during the questionnaire creation process that measuring usability for the GaaS RATK was also of the utmost importance. As a result the System Usability Score (SUS), was explored. Kabir and Han (2016) explain that the usability of an application depends on how well a software products user interfaces match the tasks users want to perform based on a set of specific constraints. Nielsen (2012) states that usability is determined by how easy a user interface is to use, and is the quality attribute that determines it. Mujinga, Eloff, and Kroeze, (2018) explain that SUS is a relatively easy and quick way to measure a user's subjective rating of an applications usability. Digging down deeper into SUS, Mujinga et al. (2018) define SUS as a 10-statement measurement tool that incorporates a Likert scale for SUS statement scoring. It should be noted that SUS has a history going back as far as 1996, where Brooke (1996), introduces it as a quick and dirty usability scale. Brooke (1996) also notes that doing a full usability assessment based on all contextual factors would be quite costly. As a result he invented a cost effective and efficient SUS scale to measure a systems usefulness based on a user's subjective perception. Since usability of the GaaS RATK contributes to whether it has worth to the user; as well as possibly contributing to the perception of usefulness to the user, we incorporated the standard SUS scale, as a part of determining usability. The outcomes of the SUS data will be presented in Section 5.1.3.

The GaaS RATK questionnaire incorporates all of the above scales. These scales were chosen as they have been proven valid and reliable in the academic studies cited above. In the end a 73-item survey was created that consisted of 16 general demographics items and 57 5-point Likert scale items (1 for strongly disagree and 5 for strongly agree). Participant recruitment and data collection will be discussed in Section 5.1.3.

The questionnaire created was based on the above models and was subject to educational and industry research standards. Athabasca University requires a standard Ethics Review, before university members conduct research projects that involve human subjects. An ethics review was performed and the research experiment was approved, with the created questionnaire being an integral part of the review. It was of the upmost importance to establish these ethical guidelines, principals, standards and thresholds, in regards to professional treatment of participants.

5.1.3 Participant Recruitment and Data Collection

The GaaS RATK experiment and participant recruitment model was vetted through the Athabasca University research ethics process. Educational Professionals for this experiment were recruited from within a K-12 education system. The Northern Lights School Division No. 69, has many educational professionals from varying age ranges, interests and backgrounds, some of whom are also researchers pursuing higher education. Recruitment occurred on-site using private social media, mailing lists and verbal site recruitment. Lab space for the experiment was kindly provided by the school division, and the experiment was set up to specification within this environment. After the design and implementation of the GaaS RATK, the experiment was conducted in November of 2017.

One of the main goals was to attract volunteers who could be participants in the experiment for this thesis. Once ethical approval was received, posters and a communications release advertising the research experiment within Northern Lights School Division Schools was released to possible participants, and disseminated through email distribution lists. Word of mouth was also used to attract potential participants. Only adults were used in this experiment, so that implied consent would only be needed on the survey for data collection. In the end via all methods relayed above, the experiment was able to attract 60 participants. All participants were provided an information package that explained the experiment in detail, highlighted it was anonymous, and explained any opt-out procedures.

The research experiment was completely anonymous and was spread out over several days. The first part of the experiment implemented several workstations and devices in a lab environment so that users could become familiar with the GaaS RATK. The lab environment consisted of a series of GaaS RATK client systems, with matching GaaS servers. The GaaS servers were isolated on a VLAN for this experiment on the local LAN, so as to yield the most realistic GaaS results.

Although the local LAN/WAN network for the school division is quite robust, there exist bottlenecks like any other network. The GaaS Servers were put on a separate VLAN, so that the GaaS RATK had to cross the internet like any other GaaS Client (Public NAT'd front facing Class C internet addresses were provided to the server machines to ensure they appeared as GaaS servers on the internet). It should also be noted, that the GaaS RATK test environment had reasonably to robust usage like any network does. Within this facility, media streaming, and bandwidth intensive software and web 2.0 resources are being used for learning purposes in other rooms that are on the same network. Although the ET/IT department in this facility does its best to evenly distribute bandwidth resources, no special Quality of Service was given to any client on the network, this applied to the GaaS RATK experiment as well. It was a goal to reproduce standard GaaS operating environments as much as possible. A quick guided tutorial was provided to all participants, and then they were left for about 5 minutes to try the interface out on their own. After this the users launched a game from the GaaS RATK, and played the GaaS video game for short period of time (Experience a vanilla GaaS play session).

Since the participants had already had a tutorial, they were then encouraged to use the features of the GaaS RATK, to see if it was possible to further optimize the GaaS experience, and to see if they found the GaaS RATK features useful (Diagnostic, results storage, static optimization etc.) useful. The participants were left to their own devices for a period of about 5 to 10 minutes to use the GaaS RATK.

After the lab experiment was complete, the participant was then asked to fill out the survey to assess their perception of the GaaS RATK. The survey was hosted within Lime Survey at Athabasca University to ensure private and secure hosting of the data. It was important that the data be housed in Canada. Even though the survey was anonymous, industry best standards such as ITIL, CIPS and ISO 27001 were applied to housing the data. It was explained on a welcome page before the survey started, that there was no way to track the survey except via a random code. The random code was provided via a link on the survey page. It should be noted that we encouraged all participants to fill out the survey as soon as possible, but since the survey was hosted on the internet, they were welcome to fill it out at a later date. It was also explained when we wanted all the results by, and how long they had to fill out the survey after the experiment. Most participants were kind with their time, in regards to the survey, since they knew I needed the data was needed for analysis as soon as possible.

5.2 Validity and Reliability Analysis

After the data from the survey was collected, it was exported, properly coded and then imported into IBM SPSS Statistics 25 for analysis. All of the data for the GaaS RATK collected from the survey is Quantitative numerical and categorical data that was assessed and measured for results. The first step was to confirm the data's reliability and validity. In total 61 participants filled out the survey. As a result a series of 9 validity and readability iterations were run against the data using IBM SPSS. During the iterations and data review it was discovered that one of the participants stated that (s)he played video games more than 20 hours on a normal week day, which is suspect since most of the participants are working professionals of adult age. The other two deleted participants said they started playing video games before they were born, which is more than likely an error. As a result three participants were initially removed since their data was more than likely incorrect. After these steps were performed, and that data cleaned, we ran the first iteration of our validity and reliability tests. It should be noted that the data was reviewed and coded by the author and then vetted through Dr. Maiga Chang.

5.2.1 Iteration 1 (Reliability and Validity)

For the first run of the reliability test, we applied the Cronbach Alpha for reliability purposes to test internal consistency. Below is an outcomes table for Cronbach's internal consistency. Table 6, represents Cronbach's Alpha for Internal Consistency.

Table 6. Cronbach's Alpha Internal Consistency

Cronbach's Alpha Internal Consistency	
$0.9 \leq \alpha$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

The Cronbach Alpha Internal Consistency Table, was constructed referencing the work of (Tavakol, 2011). The first reliability test consisted of the 58 participants, and all 57 scale items from the questionnaire. The questionnaire data was imported and run through SPSS. Cronbach's Alpha results are below:

Table 7. Cronbach Alpha internal consistency and reliability results

Subscale	Factors Affecting System's Usability	Items	Cronbach's alpha if item deleted	Cronbach's alpha
Attitude Toward Use	Attitude Toward Use	ATU – A16 ATU – A17 ATU – A18 ATU – A19	0.942 0.943 0.940 0.952	0.957
Effectiveness **0.927**	Ease of Learning	EOL – A20 SUS EOL – A21 SUS EOL – A22 EOL – A23 EOL – A24	0.652 0.638 0.623 0.901 0.627	0.732
	Ease of Use	EOU – A25 SUS EOU – A26 SUS EOU – A27 SUS EOU – A28 SUS EOU – A29 SUS	0.896 0.882 0.896 0.858 0.881	0.904
	User Interface Design	UID – A30 UID – A31 UID – A32 UID – A33 UID – A34 UID – A35	0.892 0.913 0.887 0.896 0.911 0.891	0.914
Efficiency **0.957**	Information	INFO – A36 INFO – A37 INFO – A38 INFO – A39 INFO – A40	0.908 0.919 0.904 0.914 0.911	0.928
	Usefulness	USFL – A41 USFL – A42 USFL – A43 USFL – A44 USFL – A45	0.884 0.885 0.868 0.929 0.905	0.915
Satisfaction **0.964**	Behavioral Intention to Use	BITU – A46 SUS	0.957 0.952 0.946	0.963

Expectation		BITU – A47	0.946	
		SUS	0.949	
		BITU – A48	0.980	
		BITU – A49		
		BITU – A50		
		BITU – A51		
		EXPT – A52	0.931	0.933
		EXPT – A53	0.941	
		EXPT – A54	0.889	
		EXPT – A55	0.898	
CGAS **0.976** Cognition Confidence Learning		CON – A56	0.994	0.996
		CON – A57	0.994	
		CON – A58	0.996	
		CON – A59	0.996	
		LRN – A60	0.972	0.928
		LRN – A61	0.896	
		LRN – A62	0.886	
		LRN – A63	0.886	
Affection	Liking	LIK – A64	0.949	0.954
		LIK – A65	0.954	
		LIK – A66	0.925	
		LIK – A67	0.923	
Behavior	Leisure	LEI – A68	0.973	0.975
		LEI – A69	0.964	
		LEI – A70	0.963	
		LEI – A71	0.969	
		LEI – A72	0.975	

Table 7, represents the Cronbach Alpha internal consistency and reliability results. All of the items for each of the factors are in the acceptable range, however it was quickly discovered that the Ease of Learning, Usefulness, Behavior Intention to Use and Expectation’s internal consistency and reliability could be approved if items A23, A44, A51 and A53 were removed. The CGAS 2014 is already a proven scale, and is based off of previous research, so not so surprising; all of its internal consistency results are in the excellent range. Although consistency is in the excellent range for all dimensions and factors, validity is important as well. Below are the first run validity results. For validity we perform dimension reduction using PCA (Principal Component Analysis). The following are the results of the first factor analysis run in SPSS.

Table 8. Factor Analysis PCA Results Iteration 1

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
ATU-A18	.951	58	4.57	.534.
ATU-A16	.946	58	4.53	.503
ATU-A17	.945	58	4.55	.502
ATU-A19	.925	58	4.57	.500

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
EFF-EOL-A22	.922	58	4.48	.538
EFF-EOL-A24	.894	58	4.47	.537
EFF-EOL-A21	.860	58	4.55	.502
EFF-EOL-A20	.820	58	4.57	.500
EFF-EOL-A23	.294	58	4.24	1.031

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
EFF-EOU-A28	.937	58	4.66	.479
EFF-EOU-A29	.867	58	4.67	.473
EFF-EOU-A26	.859	58	4.64	.552
EFF-EOU-A25	.802	58	4.47	.537
EFF-EOU-A27	.798	58	4.60	.493

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
EFF-UID-A32	.899	58	4.78	.421
EFF-UID-A35	.876	58	4.78	.421
EFF-UID-A30	.874	58	4.72	.451
EFF-UID-A33	.851	58	4.69	.467
EFF-UID-A34	.772	58	4.67	.473
EFF-UID-A31	.757	58	4.74	.442

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
EFI-INFO-A38	.909	58	4.69	.467
EFI-INFO-A36	.891	58	4.66	.515
EFI-INFO-A40	.886	58	4.60	.528
EFI-INFO-A39	.874	58	4.72	.451
EFI-INFO-A37	.849	58	4.69	.467

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
EFI-USFL-A43	.953	58	4.71	.459
EFI-USFL-A41	.902	58	4.67	.473
EFI-USFL-A42	.901	58	4.66	.479
EFI-USFL-A45	.843	58	4.60	.528
EFI-USFL-A44	.721	58	4.86	.348

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
SAT-BITU-A49	.981	58	4.64	.485
SAT-BITU-A48	.981	58	4.64	.485
SAT-BITU-A50	.964	58	4.66	.479
SAT-BITU-A47	.950	58	4.60	.528
SAT-BITU-A46	.909	58	4.64	.485
SAT-BITU-A51	.699	58	4.83	.381

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
SAT-EXP-A55	.961	58	4.76	.432
SAT-EXP-A54	.958	58	4.78	.421
SAT-EXP-A52	.877	58	4.76	.432
SAT-EXP-A53	.858	58	4.72	.451

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
CGAS-CON-A56	.997	58	4.26	1.001
CGAS-CON-A57	.997	58	4.26	1.001
CGAS-CON-A58	.993	58	4.29	.973
CGAS-CON-A59	.993	58	4.26	1.018

Extraction Method: Principal Component Analysis.
a. 1 comp

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
CGAS-LRN-A63	.974	58	4.86	.348
CGAS-LRN-A62	.974	58	4.86	.348
CGAS-LRN-A61	.933	58	4.83	.381
CGAS-LRN-A60	.868	58	4.79	.614

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
CGAS-LIK-A67	.969	58	4.45	.820
CGAS-LIK-A66	.965	58	4.47	.821
CGAS-LIK-A64	.932	58	4.69	.598
CGAS-LIK-A65	.911	58	4.66	.664

Component Matrix[a]

	Component 1	N	Mean	Std. Deviation
CGAS-LEI-A70	.979	58	4.52	.778
CGAS-LEI-A69	.976	58	4.53	.754

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

CGAS-LEI-A71	.953	58	4.50	.843
CGAS-LEI-A68	.941	58	4.64	.693
CGAS-LEI-A72	.936	58	4.43	.920

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Table 8, is a representation of the PCA for Iteration 1. In relation to the Cronbach Alpha, the factor analysis (PCA) for all components individually show that A23, A44, A51 and A53 are either not correlated, or not as strongly correlated to the other items, and are effecting the validity of the data. To prove the data is reliable and valid, these items were removed for the next run. Through several evolutionary iterations, in total 11 other items that were not as strongly correlated and or did not have good internal consistency were also removed. The result of the evolutionary iterations was the next substantial data run, which is iteration 2.

5.2.2 Iteration 2 (Reliability and Validity)

After all items which did not have good internal consistency, or were not strongly related to the other data were removed, iteration 2 was narrowed down to 46 items, and still had 58 respondents. It became clear that the evolutionary reliability, validity and factor analysis runs were necessary and needed, as iteration 2 of the questionnaire had an overall internal consistency and reliability of 0.982, which falls into the excellent range for outcomes. The following are the results for the Cronbach's alpha for all items and their related factor and dimensions.

Table 9. Cronbach's Alpha Iteration 2 - Reliability

Subscale	Factors Affecting System's Usability	Items	Cronbach's alpha if item deleted	Cronbach's alpha
Attitude Toward Use	Attitude Toward Use	ATU – A16 ATU – A17 ATU – A18 ATU – A19	0.942 0.943 0.940 0.952	0.957
Effectiveness **0.935** Ease of Learning Ease of Use User Interface Design		EOL – A20 SUS EOL – A21 SUS EOL – A22 EOL – A24	0.902 0.882 0.839 0.862	0.901
		EOU – A26 SUS EOU – A28 SUS EOU – A29 SUS	0.939 0.803 0.871	0.910
		UID – A30 UID – A32 UID – A33 UID – A34 UID – A35	0.903 0.890 0.886 0.906 0.883	0.913
Efficiency	Usefulness	USFL – A41 USFL – A42 USFL – A43 USFL – A44 USFL – A45	0.884 0.885 0.868 0.929 0.905	0.915
Satisfaction **0.956** Behavioral Intention to Use Expectation		BITU – A46 SUS BITU – A47 SUS BITU – A48 BITU – A49 BITU – A50	0.987 0.975 0.970 0.970 0.975	0.980
		EXPT – A52 EXPT – A54 EXPT – A55	0.976 0.896 0.863	0.941
CGAS **0.973** Cognition Confidence		CON – A56 CON – A57 CON – A58 CON – A59	0.994 0.994 0.996 0.996	0.996

Learning		LRN – A60 LRN – A61 LRN – A62 LRN – A63	0.972 0.896 0.886 0.886	0.935
CGAS Affection	Liking	LIK – A64 LIK – A65 LIK – A66 LIK – A67	0.949 0.954 0.925 0.923	0.948
CGAS Behavior	Leisure	LEI – A68 LEI – A69 LEI – A70 LEI – A71 LEI – A72	0.973 0.964 0.963 0.969 0.975	0.968

Table 9, represents Cronbach's Alpha for Iteration 2 at this stage, all the items are reliable and have excellent internal consistency. All items for each factor and dimensions for Cronbach are now in the 0.9 ≤ α range, showing great reliability. Further validity tests were conducted to make sure all of the items and factors were correlated for each dimension. Factor Analysis PCA was conducted for each item, their related factor and dimension.

Table 10. Factor Analysis PCA Results Iteration 2

Component Matrix[a]				
	Component			
	1	N	Mean	Std. Deviation
ATU – A18	.951	58	4.57	.534.
ATU – A16	.946	58	4.53	.503
ATU – A17	.945	58	4.55	.502
ATU – A19	.925	58	4.57	.500
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]				
	Component			
	1	N	Mean	Std.Deviation
EFF- EOL – A22	.932	58	4.48	.538
EFF- EOL – A24	.899	58	4.47	.537
EFF- EOL – A21	.860	58	4.55	.502
EFF- EOL – A20	.820	58	4.57	.500

Extraction Method: Principal Component Analysis.			
a. 1 components extracted.			

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
EFF – EOU-A28	.963	58	4.66	.479
EFF – EOU-A29	.927	58	4.67	.473
EFF – EOU-A26	.882	58	4.64	.552
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
EFF-UID-A35	.898	58	4.78	.421
EFF-UID-A33	.885	58	4.69	.467
EFF-UID-A32	.878	58	4.78	.421
EFF-UID-A30	.835	58	4.72	.451
EFF-UID-A34	.822	58	4.67	.473
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
EFI-USFL-A43	.953	58	4.71	.459
EFI-USFL-A41	.902	58	4.67	.473
EFI-USFL-A42	.901	58	4.66	.479
EFI-USFL-A45	.843	58	4.60	.528
EFI-USFL-A44	.721	58	4.86	.348

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
SAT-BITU-A49	.988	58	4.64	.485
SAT-BITU-A48	.988	58	4.64	.485
SAT-BITU-A47	.966	58	4.60	.528

Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

SAT-BITU-A50	.966	58	4.66	.479
SAT-BITU-A46	.908	58	4.64	.485
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
SAT-EXP-A55	.976	58	4.76	.432
SAT-EXP-A54	.958	58	4.78	.421
SAT-EXP-A52	.902	58	4.76	.432
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
CGAS-CON-A56	.997	58	4.26	1.001
CGAS-CON-A57	.997	58	4.26	1.001
CGAS-CON-	.993	58	4.29	.973

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
CGAS-LRN-A63	.974	58	4.86	.348
CGAS-LRN-A62	.974	58	4.86	.348
CGAS-LRN-	.933	58	4.83	.381

A58				
CGAS-CON-A59	.993	58	4.26	1.018
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

A61				
CGAS-LRN-A60	.868	58	4.79	.614
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
CGAS-LIK-A67	.969	58	4.45	.820
CGAS-LIK-A66	.965	58	4.47	.821
CGAS-LIK-A64	.932	58	4.69	.598
CGAS-LIK-A65	.911	58	4.66	.664
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
CGAS-LEI-A70	.979	58	4.52	.778
CGAS-LEI-A69	.976	58	4.53	.754
CGAS-LEI-A71	.953	58	4.50	.843
CGAS-LEI-A68	.941	58	4.64	.693
CGAS-LEI-A72	.936	58	4.43	.920
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Table 10, houses the results for the PCA analysis for iteration 2. The results for the PCA show that all factors except one, have excellent correlation of $0.9 \leq \alpha$ with each other, showing relational influence, and good validity. Only one item (A44) for the Efficiency dimension (usefulness), had an acceptable score of 0.721, which lies in the acceptable range. After another review of the data and through the evolutionary iterations, it becomes clear that in the end, if the information factor items were removed, that internal consistency (reliability), and factor analysis PCA (validity) would move into the excellent range, showing that the questionnaire is reliable and valid (correlated). As the next step it was important to explore multiple factor analysis for Effectiveness (user interface design, ease of use and ease of learning.), for reliability, validity and internal consistency. Table 11 houses the Multiple PCA for Iteration 2.

Table 11 – Multiple PCA for Iteration 2

Rotated Component Matrix[a]

	Component			N	Mean	Std. Deviation
	1	2	3			
35 USE [Effectiveness] User Interface Design	.851	.117	.275	58	4.78	.421
34 Usability [Effectiveness] User Interface Design	.835	-.097	.305	58	4.67	.473
32 Usability [Effectiveness] User Interface Design	.814	.389	.067	58	4.78	.421
33 Usability [Effectiveness] User Interface Design	.789	.251	.281	58	4.69	.467
30 CSUQ [Effectiveness] User Interface Design	.723	.474	.140	58	4.72	.451
29 SUS [Effectiveness] Ease of Use	.212	.890	.218	58	4.67	4.73
28 SUS [Effectiveness] Ease of Use	.202	.847	.361	58	4.66	4.79
26 SUS [Effectiveness] Ease of Use	.069	.688	.545	58	4.64	.552
22 TAM [Effectiveness] Ease of Learning	.288	.347	.823	58	4.48	.538
24 USE [Effectiveness] Ease of Learning	.238	.335	.799	58	4.47	.537
21 SUS [Effectiveness] Ease of Learning	.311	.486	.644	58	4.55	.502

20 SUS [Effectiveness] Ease of Learning	.585	.096	.636	58	4.57	.500

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

5.2.3 Iteration 3 Reliability and Validity

After the multifactor analysis was performed, we can see that when the subscale and factors are grouped they have good internal consistency (reliability), are valid and related, and are within the acceptable range. The multi PCA also shows that there is rational influence among the factors.

Upon examining the last iteration, several evolutionary reliability and validity tests that were performed indicated that Efficiency and Information (Info) could be removed. The Cronbach and PCA iterations and evolutions indicated these factors did not heavily influence any other factors. For this iteration, it was realized that there were another three problem participant records that could be slightly effecting reliability and validity. There was only one participant belonging to generation O (baby boomers, age 45 and older) which could skew the results. Moreover, there were also only two participants in the Healthcare and Social Sciences field. It was realized, these records would affect the verification of the hypotheses as well as the validity and reliability. As a result, these records were removed. After these records were removed, the collected data had 55 participants' responses for 46 items. The following are the final results. Table 12, houses Cronbach's Alpha for Iteration 3.

Table 12 . Cronbach's Alpha Iteration 3 - Reliability

Subscale	Factors Affecting System's Usability	Items	Cronbach's alpha if item deleted	Cronbach's alpha
Attitude Toward Use	Attitude Toward Use	ATU – A16 ATU – A17 ATU – A18 ATU – A19	0.938 0.939 0.936 0.949	0.955
Effectiveness **0.940**	Ease of Learning	EOL – A20 SUS EOL – A21 SUS EOL – A22 EOL – A24	0.894 0.870 0.828 0.854	0.893
	Ease of Use	EOU – A26 SUS EOU – A28 SUS EOU – A29 SUS	0.933 0.822 0.896	0.920
	User Interface Design	UID – A30 UID – A32 UID – A33 UID – A34 UID – A35	0.910 0.895 0.895 0.915 0.892	0.920
Efficiency	Usefulness	USFL – A41 USFL – A42 USFL – A43 USFL – A44 USFL – A45	0.899 0.899 0.883 0.935 0.913	0.924
Satisfaction **0.957**	Behavioral Intention to Use	BITU – A46 SUS BITU – A47 SUS BITU – A48 BITU – A49 BITU – A50	0.986 0.973 0.968 0.968 0.973	0.979
	Expectation	EXPT – A52 EXPT – A54 EXPT – A55	0.975 0.894 0.861	0.940
CGAS **0.973** Cognition	Confidence	CON – A56 CON – A57 CON – A58 CON – A59	0.994 0.994 0.996 0.996	0.996

	Learning	LRN – A60 LRN – A61 LRN – A62 LRN – A63	0.972 0.896 0.886 0.886	0.935
CGAS Affection	Liking	LIK – A64 LIK – A65 LIK – A66 LIK – A67	0.949 0.954 0.925 0.923	0.948
CGAS Behavior	Leisure	LEI – A68 LEI – A69 LEI – A70 LEI – A71 LEI – A72	0.973 0.964 0.963 0.969 0.975	0.968

The overall Cronbach Alpha is 0.982, which is in the excellent range for internal consistency. All subscales, factors and items now reside in 0.9 ranges, which is excellent. We can state that the questionnaire is reliable. Next a final factor PCA was run, and all of the results were correlated for individual factors and also for dimensions, which the data below shows. Table 13, houses the PCA for Iteration 3.

Table 13. Factor Analysis PCA Results Iteration 3

Component Matrix[a]				
	Component			
	1	N	Mean	Std. Deviation
ATU-A18	.948	55	4.58	.534
ATU-A16	.943	55	4.55	.503
ATU-A17	.942	55	4.56	.501
ATU-A19	.920	55	4.58	.498
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]				
	Component			
	1	N	Mean	Std. Deviation
EFF-EOL-A22	.926	55	4.51	.505
EFF-EOL-A24	.888	55	4.49	.505
EFF-EOL-A21	.856	55	4.56	.501
EFF-EOL-A20	.809	55	4.58	.498
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
EFF-EOU-A28	.966	55	4.67	.474
EFF-EOU-A29	.924	55	4.69	.466
EFF-EOU-A26	.899	55	4.65	.517
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
EFI-USFL-A43	.955	55	4.71	.458
EFI-USFL-A42	.906	55	4.67	.474
EFI-USFL-A41	.903	55	4.67	.474
EFI-USFL-A45	.857	55	4.64	.485
EFI-USFL-A44	.755	55	4.85	.356
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
EFF-UID-A35	.902	55	4.76	.429
EFF-UID-A32	.896	55	4.78	.417
EFF-UID-A33	.891	55	4.67	.474
EFF-UID-A30	.845	55	4.73	.449
EFF-UID-A34	.826	55	4.65	.480
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component	N	Mean	Std. Deviation
	1			
SAT-BITU-A49	.987	55	4.64	.485
SAT-BITU-A48	.987	55	4.64	.485
SAT-BITU-A47	.964	55	4.60	.531
SAT-BITU-A50	.964	55	4.65	.480
SAT-BITU-A46	.903	55	4.64	.485
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
SAT-EXP-A55	.976	55	4.76	.440
SAT-EXP-A54	.958	55	4.76	.429
SAT-EXP-A52	.900	55	4.75	.440
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

	Component			
	1	N	Mean	Std. Deviation
CGAS-CON-A56	.996	55	4.31	.979
CGAS-CON-A57	.996	55	4.31	.979
CGAS-CON-A58	.992	55	4.35	.947
CGAS-CON-A59	.992	55	4.31	.998
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
CGAS-LRN-A63	.971	55	4.87	.336
CGAS-LRN-A62	.971	55	4.87	.336
CGAS-LRN-A61	.930	55	4.84	.373
CGAS-LRN-A60	.864	55	4.84	.501
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			
	1	N	Mean	Std. Deviation
CGAS-LIK-A67	.963	55	4.47	.766
CGAS-LIK-A66	.958	55	4.49	.767
CGAS-LIK-A64	.919	55	4.71	.567
CGAS-LIK-A65	.897	55	4.67	.640
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Component Matrix[a]

	Component			

	1	N	Mean	Std. Deviation
CGAS-LEI-A70	.974	55	4.55	.715
69 CGAS [Behavior] Leisure	.969	55	4.56	.688
CGAS-LEI-A71	.943	55	4.53	.790
CGAS-LEI-A72	.928	55	4.45	.878
CGAS-LEI-A68	.927	55	4.67	.610
Extraction Method: Principal Component Analysis.				
a. 1 components extracted.				

Table 14. Factor Analysis for PCA Iteration 3 (Multiple Factors Per Dimension)

Rotated Component Matrix[a]

	Component 1	2	3	N	Mean	Std. Deviation
EFF-UID-A32	**.838**	.357	.088	55	4.78	.417
EFF-UID-A35	**.835**	.160	.313	55	4.76	.429
EFF-UID-A34	**.826**	-.032	.324	55	4.65	.480
EFF-UID-A33	**.765**	.325	.313	55	4.67	.474
EFF-UID-A30	**.703**	.444	.217	55	4.73	.449
EFF-EOU-A29	.239	**.892**	.138	55	4.69	.466
EFF-EOU-A28	.211	**.869**	.300	55	4.67	.474
EFF-EOU-A26	.132	**.790**	.421	55	4.65	.517
EFF-EOL-A24	.285	.316	**.788**	**55**	4.49	.505
EFF-EOL-A22	.352	.347	**.784**	**55**	4.51	.505
EFF-EOL-A21	.273	.498	**.671**	**55**	4.56	.501
EFF-EOL-A20	.608	.082	**.609**	**55**	4.59	.498

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Rotated Component Matrix[a]

Component

	1	2	N	Mean	Std. Deviation
SAT-BITU-A49	**.942**	.305	55	4.64	.485
SAT-BITU-A48	**.942**	.305	55	4.64	.485
SAT-BITU-A47	**.900**	.343	55	4.60	.531
SAT-BITU-A50	**.899**	.353	55	4.65	.480
SAT-BITU-A46	**.808**	.401	55	4.64	.585
SAT-EXP-A55	.326	**.917**	**55**	4.75	.440
SAT-EXP-A54	.398	**.868**	**55**	4.76	.429
SAT-EXP-A52	.279	**.865**	**55**	4.75	.440

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Rotated Component Matrix[a]

	Component		N	Mean	Std. Deviation
	1	2			
CGAS-CON-A59	**.969**	.213	55	4.31	.998
CGAS-CON-A55	**.965**	.247	55	4.75	.440
CGAS-CON-A57	**.965**	.247	55	4.31	.979
CGAS-CON-A58	**.958**	.257	55	4.35	.947
CGAS-CON-A63	.248	**.938**	**55**	4.87	.336
CGAS-CON-A62	.248	**.938**	**55**	4.87	3.36
CGAS-CON-A61	.215	**.905**	**55**	4.84	.373
CGAS-CON-A60	.196	**.843**	**55**	4.84	.501

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Table 14, houses the multiple PCA for Iteration 3. The last iteration leads to an evolution of the data that proves that the questionnaire is both valid and reliable. All dimensions, factors and their items are now in the excellent range, proving that the questionnaire is reliable and has good internal consistency via Cronbach's Alpha. Continuing with the factor analysis PCA, all items are in the $0.8 \leq \alpha < 0.9$ and $0.9 \leq \alpha$ range which is considered good and excellent, this also shows that the single and multiple factor items are now correlated.

5.3 Data Analysis and Results

In the following subsections, the data analysis and results are presented. In section 5.3.1 Gender distribution and some demographic information that may be of interest to the reader is presented. The hypothesis based on the constructs of the Macro and Micro research models are presented next. In section 5.3.2, the results of the Micro research model hypothesis statements are presented. In section 5.3.3 the results of the Macro research model hypothesis statements are presented.

The Data Analysis and the hypothesis verification process are presented with results. The motivation of these results is to prove the hypothesis, and how the constructs relate to the GaaS RATK. The data results also help to explain how the constructs are related to the GaaS RATK, and the research models. The Micro and Macro research model constructs relation, whether positive or negative help to clarify the occurrence of perception changes toward the usefulness and usability of the GaaS RATK. The Pearson Correlation test is used for the hypothesis statement verification and results process.

5.3.1 Gender Distribution Demographics

Our age groups consisted of adult aged Millennials (Generation Z) which was compromised of anyone below 30 years old or younger, and Generation X which consisted of anyone over 30 years old, yet younger than 45 years old. The majority of the participants resided in the Generation X group. This GaaS RATK research study consisted of 37 adult males and 18 adult females that varied in age and education background all working within a K-12 educational system. In Table 15, we see the GaaS RATK Gender Distribution.

Table 15. Gender Distribution

		Frequency	Percent
Valid	Female	18	32.7
	Male	37	67.3
	Total	55	100.0

Most of the participants would have grown up in the golden age of video games 1975 and beyond. Kent (2001) states that during this time Atari creates home pong and sells the idea to Sears. Meanwhile the Japanese company Namco begins making video games and a strapped for cash Nolan Bushnell approaches venture capitalists to create a home console system later to become the Atari 2600. Millennials grew up with the video game industry well established as an entertainment giant, surpassing the movie industry in value.

Table 16. Age Group Distribution

		Frequency	Percent
Valid	Gen X	37	67.3
	Gen Z	18	32.7
	Total	55	100.0

5.3.2 Micro Research Model Hypothesis Statements.

Table 16 lists the result of Pearson correlation test and shows that perceived Effectiveness of the GaaS RATK relates to a user's perceived efficiency of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H1 "Perceived Effectiveness of the GaaS RATK will strongly relate to Efficiency" is therefore supported. The data collected asked several questions about effectiveness and efficiency while also collecting the results of the user's general satisfaction with the GaaS RATK. If the user found that the GaaS RATK was effective at optimizing the GaaS Experience, and was effective in improving the experience, the user then has a favorable perception of the efficiency of the GaaS RATK. Table 17, shows the efficiency in relation to Attitude towards Use.

Table 17. Pearson Correlation Test for H1

		EFF	USFL (Efficiency)
EFF	Pearson Correlation	1	.782**
	Sig. (2-tailed)		.000
	N	55	55
USFL (Efficiency)			
	Sig. (2-tailed)	.000	
	N	55	55

Table 18 lists the result of the Pearson correlation test and shows that Efficiency of the GaaS RATK does relate to one's Attitude toward Use of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H2 "Perceived Effectiveness of the GaaS RATK, will relate to Attitude Toward Use" is therefore supported. One SUS item was accidently removed from the questionnaire in error. As a result of the accidental omission, the maximum and minimum score of SUS was calculated, based on the best and worst responses that participants may have for the missing item. Even in the worst case, the SUS score was still favorable. The minimum and the maximum SUS score the GaaS RATK received from the fifty-five participants are 90 and 100. According to Brooke (2013), if a system receives a SUS score higher than 68 it can be considered acceptable.

Table 18. Pearson Correlation Test for H2

		EFF	ATU
EFF	Pearson Correlation	1	.694**
	Sig. (2-tailed)		.000
	N	55	55
ATU			
	Sig. (2-tailed)	.000	
	N	55	55

Table 19 lists the result of Pearson correlation test and shows that Effectiveness of the GaaS RATK does relate to the GaaS RATK's SUS score. As well, we can see that the correlation is significant. Hypothesis H3 "Effectiveness of the GaaS RATK will strongly relate toUsability" is therefore supported.

Table 19. Pearson Correlation Test for H3

		EFF	SUS (max)	SUS (min)
EFF	Pearson Correlation	1	.922**	.922**
	Sig. (2-tailed)		.000	.000
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 20 lists the results of the Pearson correlation test and shows that Effectiveness of the GaaS RATK does relate to Satisfaction of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H4 "Effectiveness of the GaaS RATK will strongly relate to satisfaction" is therefore supported.

Table 20. Pearson Correlation Test for H4

		EFF	SAT
EFF	Pearson Correlation	1	.783**
	Sig. (2-tailed)		.000
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 21 lists the result of the Pearson correlation test and shows that Efficiency of the GaaS RATK does relate to Satisfaction of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H5 “Perceived Efficiency of the GaaS RATK will affect Satisfaction" is therefore supported.

Table 21. Pearson Correlation Test for H5

		USFL (Efficiency)	SAT
USFL (Efficiency)	Pearson Correlation	1	.878**
	Sig. (2-tailed)		.000
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 22 lists the result of the Pearson correlation test and shows that Efficiency of the GaaS RATK does relate to System Usability of the GaaS RATK. Furthermore, we can see that the correlation is significant. Hypothesis H6 “Perceived Efficiency of the GaaS RATK will affect Usability” is therefore supported.

Table 22. Pearson Correlation Test for H6

		USFL (Efficiency)	SUS (max)	SUS (min)
USFL (Efficiency)	Pearson Correlation	1	.851**	.851**
	Sig. (2-tailed)		.000	.000
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 23 lists the result of the Pearson correlation test and shows that Satisfaction of the GaaS RATK DOES relate to one's Attitude Toward Use of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H7 "Perceived Satisfaction of the GaaS RATK will affect Attitude Toward Use" is therefore supported.

Table 23. Pearson Correlation Test for H7

		SAT	ATU
SAT	Pearson Correlation	1	.588**
	Sig. (2-tailed)		.000
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 24 lists the result of the Pearson correlation test and shows that Satisfaction of the GaaS RATK does relate to System Usability of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H8 "Perceived Satisfaction of the GaaS RATK will affect Usability" is therefore supported.

Table 24. Pearson Correlation Test for H8

		SAT	SUS (max)	SUS (min)
SAT	Pearson Correlation	1	.837**	.837**
	Sig. (2-tailed)		.000	.000
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 25 lists the result of the Pearson correlation test and shows that a user's Attitude toward the GaaS RATK does relate to the System Usability of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H9 "Perceived Satisfaction of the GaaS RATK will affect Usability" is therefore supported.

Table 25. Pearson Correlation Test for H9

		ATU	SUS (max)	SUS (min)
ATU	Pearson Correlation	1	.758**	.758**
	Sig. (2-tailed)		.000	.000
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 26 lists the result of the Pearson correlation test and shows that a user's Ease of Learning of the GaaS RATK does relate to the Efficiency of the GaaS RATK. As well, we can see that the correlation is significant. Hypothesis H10a "Perceived Ease of Learning of the GaaS RATK will affect perceived Effectiveness" is therefore supported.

Table 26. Pearson Correlation Test for H10a

		EOL	EFF
EOL	Pearson Correlation	1	.764**
	Sig. (2-tailed)		.000
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 27 lists the result of Pearson correlation test and shows that Ease of Use of the GaaS RATK does relate to one's GaaS RATK's perceived efficiency. As well, we can see that the correlation is significant. Hypothesis H10b "Perceived Ease of Use of the GaaS RATK will strongly relate to people's perceived Effectiveness." is therefore supported.

Table 27. Pearson Correlation Test for H10b

		EOU	EFF
EOU	Pearson Correlation	1	.958**
	Sig. (2-tailed)		.000
	N	55	55
EFF	Pearson Correlation	.958**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 28 lists the results of the Pearson correlation test and shows that the User Interface Design of the GaaS RATK does relate to the GaaS RATK's perceived efficiency. As well, we can see that the correlation is significant. Hypothesis H10c "The User Interface Design of the GaaS RATK will strongly relate to people's perceived Effectiveness." is therefore supported. Analyzing the Study result data further, we can see that all 55 participants that agreed or strongly agreed that the User Interface design was pleasant and functional also agreed or strongly agreed that the GaaS RATK was Effective. Another conclusion that we can now draw clearly and prove is that Ease of Learning, Ease of Use and the User Interface Design of the GaaS RATK, all contribute to the Effectiveness of the GaaS RATK, and indeed if all participants in the study had a favorable view of these 3 factors, they also had a favorable view of the GaaS RATK's effectiveness.

Table 28. Pearson Correlation Test for H10c

		UID	EFF
UID	Pearson Correlation	1	.753**
	Sig. (2-tailed)		.000
	N	55	55
EFF	Pearson Correlation	.753**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 29 lists the results of the Pearson correlation test and shows that Confidence in the GaaS RATK DOES relate to the GaaS RATK's perceived efficiency. As well, we can see that the correlation is significant. Hypothesis H10d "A participant's confidence in playing video games will strongly relate to one's perceived Effectiveness toward the GaaS RATK." is therefore supported. Analyzing the GaaS RATK study data, we can see that if a user answers that they were confident at playing video games, they would also find the

GaaS RATK to be effective. It should also be noted that there were very few participants that felt they were not confident at playing games, however these respondents still had a favorable view of the effectiveness of the GaaS RATK. In fact 6 of the respondents of the 55 that were not confident at playing games, still agreed or strongly agreed that the GaaS RATK was effective.

This bodes well for the operation and functionality of the toolkit, because even if the participant was not well versed or confident at playing video games, the data showed that they still found the toolkit easy to use and feature rich. The participant found it effective, and would still recommend or use the GaaS RATK.

Table 29. Pearson Correlation Test for H10d

		CON	EFF
CON	Pearson Correlation	1	.695**
	Sig. (2-tailed)		.000
	N	55	55
EFF	Pearson Correlation	.695**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 30 lists the result of Pearson correlation test and shows that Ease of Learning of the GaaS RATK does relate to the GaaS RATK's perceived Satisfaction. As well, we can see that the correlation is significant. Hypothesis H11a "Ease of Learning of the GaaS RATK will affect people's perceived satisfaction" is therefore supported. Analyzing the study data, we can see that all 55 participants that either agreed or strongly agreed with the GaaS RATK ease of use also agreed or strongly agreed that they were satisfied with the GaaS RATK, and its features and functions.

Table 30. Pearson Correlation test for H11a

		EOL	SAT
EOL	Pearson Correlation	1	.705**
	Sig. (2-tailed)		.000
	N	55	55
SAT	Pearson Correlation	.705**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 31 lists the result of Pearson correlation test and shows that Ease of Use of the GaaS RATK does relate to the GaaS RATK's perceived Satisfaction. As well, we can see that the correlation is significant. Hypothesis H11b "Ease of Use of the GaaS RATK will affect people's perceived satisfaction." is therefore supported.

Table 31. Pearson Correlation for H11b

		EOU	SAT
EOU	Pearson Correlation	1	.694**
	Sig. (2-tailed)		.000
	N	55	55
SAT	Pearson Correlation	.694**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 32 lists the result of Pearson correlation test and shows that the User Interface Design of the GaaS RATK does relate to the GaaS RATK's perceived Satisfaction. As well, we can see that the correlation is significant. Hypothesis H11c "The User Interface Design of the GaaS RATK will strongly relate to people's perceived Satisfaction" is therefore supported. Looking at the compiled results of the GaaS RATK study, participants agreed or strongly agreed that the GaaS RATK User interface design was good. The compiled data for Satisfaction also showed that the users who responded favorable to this also agreed or strongly agreed and said that they were satisfied with the GaaS RATK.

Table 32. Pearson Correlation for H11c

		UID	SAT
UID	Pearson Correlation	1	.717**
	Sig. (2-tailed)		.000
	N	55	55
SAT	Pearson Correlation	.717**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 33 lists the results of the Pearson correlation test and shows that Expectation of the GaaS RATK does relate to the GaaS RATK's perceived Satisfaction. As well, we can see that the correlation is significant. Hypothesis H11d "The participant's Expectation of the GaaS RATK will strongly relate to one's perceived Satisfaction" is therefore supported. If the participants' expectations were met, they would also be satisfied with the GaaS RATK. In fact all 55 participants who either agreed or strongly agreed that the GaaS RATK met their expectations were also satisfied with the GaaS RATK.

Table 33.Pearson Correlation for H11d

		EXPT	SAT
EXPT	Pearson Correlation	1	.898**
	Sig. (2-tailed)		.000
	N	55	55
SAT	Pearson Correlation	.898**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 34 lists the results of the Pearson correlation test and shows that a user's Behavioral Intention to Use the GaaS RATK does relate to the GaaS RATK's perceived Satisfaction. As well, we can see that the correlation is significant. Hypothesis H11e "A participant's behavioral intention to Use the GaaS RATK will strongly relate to one's perceived Satisfaction" is therefore supported. In this study if the participant agreed, or strongly agreed that that they would use, keep using, or recommend the GaaS RATK to others, they would also agree or strongly agree and say that they were satisfied with the GaaS RATK.

Table 34. Pearson Correlation for H11e

		BITU	SAT
BITU	Pearson Correlation	1	.924**
	Sig. (2-tailed)		.000
	N	55	55
SAT	Pearson Correlation	.924**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 35 lists the result of the Pearson correlation test and shows that a user liking video games relates to the GaaS RATK's perceived Satisfaction. As well, we can see that the correlation is significant. Hypothesis H11f "How much a participant likes video games will affect one's perceived Satisfaction toward the GaaS RATK" is therefore supported. In the study, although the majority of participants liked video games, there were some that did not. That being said, even if a user didn't like video games, they were still influenced enough with the features and functions of the GaaS RATK, that these users were still satisfied with the GaaS RATK. Since the goal of the GaaS RATK, was to find a way to easily optimize and enhance the GaaS gaming experience for even casual gamers, it is beneficial that this group was still satisfied with the GaaS RATK.

Table 35. Pearson Correlation for H11f

		LIK	SAT
LIK	Pearson Correlation	1	.701**
	Sig. (2-tailed)		.000
	N	55	55
SAT	Pearson Correlation	.701**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 36 lists the results of the Pearson correlation test and shows that a user liking video games relates to the GaaS RATK's perceived Efficiency. As well, we can see that the correlation is significant. Hypothesis H12 "How much a participant likes video games will affect one's perception of the GaaS RATK's Efficiency" is therefore supported. Not all participants Liked video games in this study, however majority of them did.

The good news is that even if one did not like video games, they still found the GaaS RATK Efficient. Once again this is a good outcome, as most users' agreed or strongly agreed on the GaaS RATK efficiency even if they were not video game lovers. The participants still agreed the GaaS RATK is efficient. This is once a again a positive outcome, because even if they didn't like video games, the participant still saw intrinsic value and also agreed that it was an efficient way to optimize, enhance or problem solve GaaS.

Table 36. Pearson Correlation for H12

		LIK	USFL (Efficiency)
LIK	Pearson Correlation	1	.629**
	Sig. (2-tailed)		.000
	N	55	55
USFL (Efficiency)	Pearson Correlation	.629**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 37 lists the results of the Pearson correlation test and shows that a user liking video games relates to the GaaS RATK's perceived Efficiency. As well, we can see that the correlation is significant. Hypothesis H13: "How much a participant likes video games will affect their Attitude Toward Use of the GaaS RATK" is therefore supported. The majority of participants, who said they agreed or strongly agreed that they liked video games, also had a favorable attitude toward the GaaS RATK's use. There was a small majority of participants who did not like video games, however, they still had a positive attitude toward the GaaS RATK, and would use it again, and or recommend it to someone else.

Table 37. Pearson Correlation for H13

		LIK	ATU
LIK	Pearson Correlation	1	.649**
	Sig. (2-tailed)		.000
	N	55	55
ATU	Pearson Correlation	.649**	1
	Sig. (2-tailed)	.000	
	N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 38 lists the results of the Pearson correlation test and shows that if a user has confidence playing video games this relates to the GaaS RATK's perceived Usability. As well, we can see that the correlation is significant. Hypothesis H14a "The participant's Confidence with playing video games will affect one's perceived Usability of the GaaS RATK" is therefore supported. Although the majority of participants had confidence with playing video games, a small minority did not, however these participants still felt that the GaaS RATK was user friendly. Once again this is a great result. Even if the participant was not confident with video games, they still agreed or strongly agreed to all SUS questions and gave the GaaS RATK a good System Usability Score.

Table 38. Pearson Correlation for H14a

Correlations

		CON	SUS (max)	SUS (min)
CON	Pearson Correlation	1	.677**	.677**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
SUS (max)	Pearson Correlation	.677**	1	1.000**
	Sig. (2-tailed)	.000		.000
	N	55	55	55
SUS (min)	Pearson Correlation	.677**	1.000**	1
	Sig. (2-tailed)	.000	.000	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Table 39 lists the results of the Pearson correlation test and shows that if a user likes playing video games this relates to the GaaS RATK's perceived Usability. As well, we can see that the correlation is significant. Hypothesis H14b "How much a participant likes video games will affect one's perceived Usability of the GaaS RATK" is therefore supported. A small minority of participants did not like video games but overwhelmingly still agreed with all of the system usability questions. This is great, because these participants still found value in the GaaS RATK, and gave it a good SUS score. Of course the main data also showed that the majority of participants that agreed or strongly agreed that they liked video games, also gave the GaaS RATK an amazing SUS score.

Table 39. Pearson Correlation for H14b

		LIK	SUS (max)	SUS (min)
LIK	Pearson Correlation	1	.749**	.749**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
SUS (max)	Pearson Correlation	.749**	1	1.000**

	Sig. (2-tailed)	.000		.000
	N	55	55	55
SUS (min)	Pearson Correlation	.749**	1.000**	1
	Sig. (2-tailed)	.000	.000	
	N	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

5.4 Findings and Discussions

In this section I discuss the common finding and important findings of the proposed research are discussed.

5.4.1 Common Findings

In Table 39, it was found; that the largest portion of the participant group was in arts, the second largest is in general sciences and our third was in engineering. By chance there is some equality between the fields of study, as the data suggests.

Table 40. Frequency of the field of study among participants

		Frequency	Percent
Valid	Arts	20	36.4
	Engineering	17	30.9
	Science	18	32.7
	Total	55	100.0

It was discovered that 17 participants were aware of GaaS, and that 38 of them were not. As Table 40 indicates, based on the descriptive statistics. We can see that in this sample group, more participants were unaware than aware of GaaS. If the participant was unaware of GaaS, we did not ask them if they currently have GaaS. Some promising and positive findings in the data show that if a user was aware of GaaS, a larger portion of the group that was aware retained their GaaS system, instead of abandoning it. Of the 17 participants who were aware of GaaS, 11 of them kept using GaaS, and only 6 currently did not maintain a GasS System. A larger percent of those participants, who were aware, kept using a GaaS System.

Table 41. Descriptive statistics of participants' GaaS usage experience

	Aware of GaaS		**Currently Have GaaS**	
	Yes	No	Yes	No
# of Participants	17	38	11	6
% of Participants	30.9	69.1	20	10.9

Gender was assessed and it was found that Gender would affect a users' Perceived Satisfaction toward the GaaS RATK. It was found that men gave a little higher score for perceived satisfaction (see Table 41). After Levene's Test for Equality of variance was assessed the p-Value of the t-test was reviewed and it was found that the data shows that males and females difference for perceived satisfaction is significant ($p = 0.000$). It should be noted that although males and females have a difference in their perception of satisfaction toward the GaaS RATK that both men and woman are favorable about their perceived satisfaction of the GaaS RATK. For all 55 participants, most of men and woman were satisfied or strongly satisfied with the GaaS RATK and its operation.

Table 42. The difference between genders in regards to perceived effectiveness of the GaaS RATK

	Descriptive Statistics			**t-test**		
	N	Mean	SD	T	df	p
Male	37	4.8694	.27175	5.283	25.251	0.000
Female	18	4.3278	.39145			

In our findings we also investigated the differences between Genders in regards to a user's perceived effectiveness of the GaaS RATK. In our investigation we found that the p-value of the t-test is 0.000, which represents that men and woman do perceive the GaaS RATK effectiveness differently (see Table 42). That being said, upon review of the mean values for the scores that men and woman gave the GaaS RATK, we can see that both genders scored the GaaS RATK high, in regards to how effective it is within the realm of its features and functions with GaaS. Based on the mean data, we can see that both genders either agreed or strongly agreed that the GaaS RATK was very effective.

Table 43. Gender differences in regards to Effectiveness of the GaaS RATK

	Descriptive Statistics			**t-test**		
	N	Mean	SD	T	df	p
Male	37	4.8438	.2967	5.202	53	0.000
Female	18	4.3691	.3575			

The next set of findings was explored to see if Gender had an affect on the Perceived Efficiency of the GaaS RATK. Table 43 lists the t-test result. The p-value is 0.001 which is less than 0.05, which means there is a significant difference between how males and females perceive the GaaS RATK's efficiency. We can also see that once again, men scored efficiency higher than woman. Taking into account different perceptions, we also can see that although men scored the efficiency higher than woman, that both either agree or strongly agree that the GaaS RATK is efficient within the realm of its present features and functions.

Table 44. Gender differences in regards to Perceived Efficiency of the GaaS RATK

	Descriptive Statistics			**t-test**		
	N	Mean	SD	T	df	p
Male	37	4.849	.3070	3.904	26.558	0.001
Female	18	4.422	.4110			

The next exploration involved looking at the findings to see how Gender affects one's Attitude Toward Use of the GaaS RATK. When one examines the result of the t-test and the resulting p-value of 0 (which is significant), it becomes clear that Gender does affect one's Attitude toward use of the GaaS RATK (see Table 44). Looking at the Mean values, we see men having a higher score for their Attitude Toward Use. All things being equal in this case, both men and woman agreed or strongly agreed that they would use the GaaS RATK again, and also recommend it to others. Both men and woman had a positive Attitude Toward use of the GaaS RATK.

Table 45. Gender differences regarding Attitude Toward Use of the GaaS RATK

	Descriptive Statistics			**t-test**		
	N	Mean	SD	T	df	p
Male	37	4.7635	.41644	5.348	53	0.000
Female	18	4.1667	.32084			

5.4.2 Important Findings

While exploring the data further in Table 45, we endeavored to see how the field of study affected one's attitude toward use. To explore this the ANOVA test was performed. An ANOVA test was performed because we are investigating three different groups in this scenario. Technically one could perform several t-tests against several different groups; however the level of error would increase, if we perform more than one t-test against different yet possibly related groups. It is best in this scenario to perform one ANOVA test, against all groups, to ensure the level of error is decreased. Based on our current findings, we now know that engineering has the best Attitude Toward Use of the GaaS RATK, with arts and then science coming in second and third. All scored results are excellent. We can also see based on the p value that the field of study significantly affects one's Attitude Toward Use. Even though field of study does affect Attitude Towards Use, we can once again see that all participants in all fields of study strongly agreed or agreed that they would continue to use or recommend the GaaS RATK to others. It is important to know that one's field of study can influence ones perception and possible enjoyment, or use of the software. In this case even though perception was affected, it seems the features and functions of the GaaS RATK were pleasurable and functional for all participants.

Table 46. How a participant's field of study affects their Attitude Toward Use of the GaaS RATK

	Descriptive Statistics			**ANOVA**		
	N	Mean	SD	F	df	p
Arts	20	4.4125	.48174	5.743	2	0.006
Engineering	17	4.8676	.08055		52	
Science	18	4.4583	.11298			

Digging deeper down, the study looked at if a participant's field of study affects their perceived effectiveness of the GaaS RATK. Referencing Table 46, the p-value of the one-way ANOVA is 0.018 which is less than 0.05, which shows that one's field of study does significantly affect one's perceived effectiveness of the GaaS RATK. However exploring the mean values of the scores of the study, we can see that the engineers' believe the GaaS RATK is the most effective, with science next, and arts last. Even though this is the case, we can see once again that all fields of study find the GaaS RATK effective either agreeing or strongly agreeing that this is so.

Table 47. Field of study and it's affect on perceived effectiveness of the GaaS RATK

	Descriptive Statistics			**ANOVA**		
	N	Mean	SD	F	df	p
Arts	20	4.6022	.43042	4.335	2	0.018
Engineering	17	4.9046	.20499		52	
Science	18	4.5802	.40050			

Next there was further examination in regards to what the data stated about the field of study and its affect on perceived efficiency of the GaaS RATK. Reviewing the ANOVA test results in Table 47, we see the p-value is $0.007<0.05$, which means the field of study that a person chooses does significantly affect their perception of efficiency in regards to the GaaS RATK. Even though this is the case, if we look at the Mean values, we can see that even though one's field of study is significantly affecting one's perception, that all students in all Arts, Engineering and the Sciences all agreed or strongly agreed that the GaaS RATK meets their efficiency expectations.

Table 48. Field of study and its affect on perceived efficiency of the GaaS RATK

	Descriptive Statistics			**ANOVA**		
	N	Mean	SD	F	df	p
Arts	20	4.59	.4278	5.452	2	0.007
Engineering	17	4.953	.1125		52	
Science	18	4.611	.4418			

Moving forward it was important to know if the Field of study affects one's perceived satisfaction with the GaaS RATK. Referencing the ANOVA test results in Table 48, we can see that the p-value is 0.001<0.05, and the field of study does indeed affect one's perceived satisfaction with the GaaS RATK. As with other earlier datasets, it is good to know that in this research field of study could affect satisfaction, as there could be times, when a participants lack of interest in GaaS, could contribute to a negative perception. However, in this study, once mean values are reviewed, we can see that all participants had a high satisfaction rate with the GaaS RATK, stating that they agree or strongly agree they are satisfied. Among these participants, and field of study group, we can see that Engineering has the highest perceived satisfaction, with arts coming in 2nd and Science coming in 3rd. Although engineering has the most satisfaction, we can also see that arts and science also have a high satisfaction rate, (in the 4 to 5 range), which is the good, to very good range. One point of interest that may help to explain the Sciences lower, yet still excellent perception towards the GaaS RATK is that the sciences consist of Biology, Chemistry and Geography. Some of these would be classified as social sciences, whereas chemistry would have a more mathematical and chemical based foundation. The decreased perception, cannot be fully explained, however one theory would be that some of the social sciences may be less inclined or interested in video games, and may not like or have as much confidence with playing and utilizing video games. One could also review the hours of video games played per week, as an indicator as well. As a result, the social sciences may pull down the perception points of the more mathematical sciences. In support of this, a visual review of the coded data was done, specifically to look at hours of video game play per week. In this examination we can see that those in the field of chemistry on average have more hours of video games played per week, than professionals in biology or geography, which for this study supports the above theory in regards to those in the fields of mathematical and social sciences.

Table 49. Field of study and its affect on perceived satisfaction of the GaaS RATK

	Descriptive Statistics			**ANOVA**			**Post-Hoc Duncan**	
	N	Mean	SD	F	df	p	1	2
Arts	20	4.5133	.4516	8.020	2	0.001	4.5133	
Engineering	17	4.9745	.0829		52			4.974
Science	18	4.624	.4022				4.624	
Duncan Significance							.357	1.000

It was important to reference the gamer type, and how this affects the perceived satisfaction of the GaaS RATK. Visually we can see from the N (the participant's number) in Table 49, that hardcore and casual gamers are almost split perfectly within this study. Reviewing the p-value of the t-test, which is 0.000<0.05, we can instantly see that if one labels themselves as a hardcore or casual gamer, that this will also influence their perception of the effectiveness toward the GaaS RATK. This could lead to worry that one may not like the GaaS RATK, just because they are not a hardcore gamer. That worry was immediately set aside upon visual review of the mean value related to the Likert scale answers of the questionnaire. Upon review we can immediately see that both the hardcore and casual gamers gave scores within the 4-5 range, which means they either agree or strongly agree that the effectiveness of the GaaS RATK meets their needs.

Table 50. Gamer type and its affect on perceived effectiveness of the GaaS RATK

	Descriptive Statistics			**t-test**		
	N	Mean	SD	T	df	p
Hardcore	27	4.9152	.17746	5.266	37.081	0.000
Casual	28	4.2698	.40948			

Exploring hardcore and casual gamers further, it was decided to see if labeling oneself as either hardcore or casual would affect one's perceived efficiency of the GaaS RATK. Referencing the t-test result in Table 50, and reviewing the p value of $0.000<0.05$, indicates that one's self labeled gamer type does indeed influence their perception of efficiency and the GaaS RATK. The perception change in this study however, was not a negative one. All 55 participants, whether they were hardcore or casual gamers all agreed or strongly agreed that the GaaS RATK was efficient for them.

Table 51. Gamer type and its affect on perceived efficiency of the GaaS RATK.

	Descriptive Statistics			**t-test**		
	N	Mean	SD	T	df	p
Hardcore	27	4.948	.1626	5.512	35.189	0.000
Casual	28	4.479	.4193			

At this point, we investigated if one's gamer type has an effect on Attitude Toward Use of the GaaS RATK. Reviewing Table 51, the p-value of the t-test result is $0.000<0.05$, which shows it is significant. The result of this is that one's gamer type does indeed influence one's Attitude Toward Use of the GaaS RATK. Reviewing mean scores based on the Likert scale in regards to the questionnaire in this study, we can see the compiled SPSS data shows very positive results. Of all 55 participants whether they be hardcore or casual, all either agreed or strongly agreed that they had a positive Attitude Toward the

Use of the GaaS RATK, and that they would either continue to use it in the future, and or recommend it to someone else.

Table 52. Gamer type and its affect on Attitude Toward Use of the GaaS RATK

	Descriptive Statistics			**t-test**		
	N	Mean	SD	T	df	p
Hardcore	27	4.8796	.28898	6.213	47.417	0.000
Casual	28	4.2679	.42995			

This study, includes the demographics, to look at whether gender affects one's chosen field of study. In order to do this a chi-squared test was performed on the data to discover the results. After the crosstab of the chi-squared was completed (see Table 52), the Asymptotic Significance value for p is 0.014<0.05, which tells us the data is significant. We now know that gender does affect one's field of study. The research cohort is dominated by individuals in math related sciences. Specifically the study group contained 16 males and 1 female in engineering. However, for general sciences, we see that males and females have equal distribution in this study. Males and females remain closely related in numbers in regards to the Arts. That being said, from the crosstab count, and the significance value, we see that scientifically in this data, gender does have an influence.

Table 53. The affect of Gender on a participants chosen field of study

	Count			**χ^2 test**		
	Female	Male	Total	χ^2	df	p
Arts	8	12	20	8.484	2	0.014
Engineering	1	16	17		2	
Science	9	9	18			

5.4.3 Summary of Findings

- Awareness of GaaS could be better, only 17 participants have heard of GaaS, leaving 38 gamers who do not know what GaaS is.
- Gender does relate to perceived Satisfaction of the GaaS RATK*
- Gender relates to perceived Effectiveness of the GaaS RATK*
- Gender relates to perceived Efficiency of the GaaS RATK*
- Gender relates to perceived Attitude Toward Use of the GaaS RATK*

- Field of Study is related to perceived Attitude Toward Use of the GaaS RATK*
- Field of Study is related to perceived Effectiveness of the GaaS RATK*
- Field of Study is related to perceived Efficiency of the GaaS RATK*
- Field of Study is related to perceived Satisfaction of the GaaS RATK*
- Gamer type is related to perceived Effectiveness of the GaaS RATK*
- Gamer type is related to perceived Efficiency of the GaaS RATK*
- Gamer type is related to perceived Attitude Toward Use of the GaaS RATK*
- Gender does have an affect on one’s chosen Field of Study

*In all instances, in this study the large majority of the participants either agreed or strongly agreed that the GaaS RATK was useful in all categories and factors. It is noteworthy to mention that perception could influence the scales of measurement and their results negatively (CGAS, SUS, TAM, Usability).

In regards to the summary of findings flow theory must be addressed. Flow theory was a part of the past research works of this thesis. It therefore should be acknowledged that flow could also play a role in the GaaS RATK findings. During the experiment, it was visually observed that when the GaaS RATK contributed to an uptake in the QoE, that the gamers seemed to be in the zone and experiencing flow.

Several observations were made as the participants played the games within the GaaS RATK realm, that could be contributed to flow. It was noted that during periods where no historical GaaS carry over errors occurred, that gamers seemed to be relaxed and experiencing flow. Previous research on the state of flow, explains that a feeling of euphoria or general wellbeing is experienced, when the state of flow is reached. When flow is occurring a general feeling of safety and wellbeing is felt. Therefore one could theorize that this experience of flow could contribute to a positive experience with the GaaS RATK, and would also relate to how a user ultimately felt about the GaaS RATK. In the end flow could influence the participants' perception and feeling that the GaaS RATK is not only useful, but also usable.

6 CHAPTER VI – CONCLUSIONS

6.1 Summary

This research presents a GaaS RATK, which has the ability to facilitate ongoing GaaS research while attempting to provide the shortest path to GaaS optimization for generational carry over GaaS issues. Researchers and gaming aficionados can use the GaaS RATK as they wish to facilitate and evolve their research, or optimize recreational use as a gamer with long-term QoE in mind. The research includes the development of an application and an optional affordable open hardware offering, which in the end constitutes the GaaS RATK. Also included are the hypotheses, experiment design, questionnaire, data results, findings and any related discussion.

Based on the data results, we see that all hypotheses were proven. In regards to the compiled data results of the questionnaire after statistical processing, we can see that all factors of the CGAS, TAM, SUS and Usability scales confirm that the GaaS RATK is useful and efficient. The participants also agreed that the GaaS RATK has a great user interface experience and had all of the features and functions that helped streamline their GaaS experience. Almost all participants also stated that they would either continue to use and or recommend the GaaS RATK to a friend or someone who would also find it useful.

It is expected that this GaaS RATK, will lead to future enhancements and evolution of GaaS while contributing to shortest path optimization while we cross the evolutionary bridge with GaaS. The ultimate goal would be that this research serves as a motivator, facilitator and acceptance navigator for GaaS and its evolutionary process. In conclusion, some of the good implications of the GaaS RATK are that gamers can use the GaaS RATK to quickly optimize the GaaS experience, which can lead to a more positive view of GaaS, and ultimately lead to greater uptake and acceptance of GaaS. The GaaS RATK can also be used as a centralized hub to test the GaaS network and server environment, and to help contribute and assist in an error free experience. Researchers can use the GaaS RATK to test their technical creations, solutions and innovations, to see if they are contributing to solving industry carry over issues with GaaS. Ultimately the GaaS RATK has been proven to be Usable and Useful, with features that contribute to optimizing the GaaS QoE. The result of this is that researchers can use the GaaS RATK to identify historical GaaS Carry over issues in their ongoing research, and additionally gamers and first time GaaS users, can optimize their experience. Taking into consideration these factors, ultimately the toolkit could help to evolve GaaS, and lead to higher acceptance of GaaS as it evolves. The GaaS RATK has positive implications in the GaaS Computer Science Research world, the video gaming realm, and has been proven to be useful by hardcore, casual gamers and researchers.

6.2 Challenges and Limitations

There were some minor issues and possible limitations to this research. For example static feedback optimization based on results assessment will prove to be a challenge. Historical research and our current research shows us, there are many GaaS systems, with fundamental technology standards applied within. These systems can be baselined and optimized for performance. There are often several components to a GaaS system that are proprietary or custom to the system itself. The good news is that, the GaaS RATK, proved to be user friendly and functional enough for most users to streamline the experience in ways they perceived as useful. Determining the best optimization across known and more prominent GaaS systems with varying algorithms for compression, may prove to be difficult as the GaaS RATK is applied to fully proprietary systems. Misuse, and human error in regards to assessment tools, will also be an issue. Optimization results may be affected by this issue. Implementing iterative cycles within the SDLC (System Design Lifecycle) should help to alleviate some of the pressures of these challenges.

Sample is always a challenge. It would be nice to have large sample size groups, and long term evaluation periods, however this is not realistic for an academic project that has resource, funding and time constraints. As a result, a right sizing of the project scope occurred so that a realistic sample size and field trial occurred to keep the project on track and realistic. The sample sizes of studies that have evaluated the effectiveness of an app within the CGAS, TAM, SUS and usability framework we reviewed. In addition the ANOVA power equation for sample sizes was also considered in regards to this research. The results indicate that the sample size of 55 participants was reasonable given the environmental, resource, funding and time constraints. There were no children in this study due to possible consent issues and time constraints. If children were included in this study, we would have needed not only consent from the school division, but also informed parental consent since all of the children and or students would be minors. Since only adults were used, only implied consent was needed, and was embedded within the GaaS RATK survey. However, minors would have provided another demographic perspective and perception of the usefulness and usability of the GaaS RATK, for the experiment. The perception of adults and children could be different, as both demographics fall into different human development cycles.

Base lining a user's perception of what a reasonable QoE improvement is for GaaS can be challenging. It was important to mediate perception based on real world measurement scales such as CGAS, TAM SUS and usability for most software systems. Presenting a vanilla GaaS baseline system, while allowing users to self-perceive its possible operational lack of optimization, will also help to manage optimization expectations. Mixed background eligibility also helped to manage expectations and the risk of unrealistic GaaS RATK expectations due to the varying acceptance of what is considered acceptable for GaaS among people of varying experience and backgrounds.

To carry out the experiment, a suitable facility with proper space and resources was secured. Athabasca University (AU) is a functional but systematically splintered and diverse facility, as it has to be, to serve a large and diverse online distance education population. To work around AU's resource constraint, the experiment was carried out within Northern Lights School Division No 69, which is a public school division. This environment has a multitude of employees from multidisciplinary backgrounds, ranging from the social sciences to technology. Many of the educators themselves have carried out research, obtained higher education and designed research experiments. The volunteers had the resources, time and authority to assist in the participant alignment process, while expressing input and opinions that helped to optimize this research experiment.

While an attempt to standardize operational functions across smart phones has been a focus, there are still vast operational bridges between Android and iOS. API and hardware functionality across all devices is not equal, which also posed a challenge. Functionality across API's on both Android and iOS are not equal. As a result functions needed, and or used for the GaaS RATK may not perform equally across all platforms. Therefore this could lead to possible inconsistent experiences, and varied future research outcomes, as the toolkit is ported to other platforms. Certain API functionality may also exist on one platform, while not on another.

6.3 Future Work

As the experiment evolves through the design and implementation process, technical and usage based shortcomings will be exposed. The GasS RATK will be evaluated further as it evolves to assess its effectiveness as a facilitator to GaaS optimization. Related research in comparison to default vanilla GaaS implementations will be evaluated for continued usefulness in general.

Outside of ongoing iterations and cycles that will refine the GaaS RATK, there are other future possibilities for this research work. The GaaS RATK could be used as a part of future evolutionary GaaS research work. The GaaS RATK can also be used as a centralized tracking, testing and optimization tool, and has the potential to be a part of the many future evolutionary GaaS works that are coming down the pipeline.

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APPENDIX A – The GaaS Ratk Qestionnaire

Ques #	Origin	Origin #	Factor HL	Factor	Item #	Item (Matthew Stavert	Reference
1	TAM	21	Attitude toward Use	Attitude toward Use	1	I believe it's a good idea to use a GaaS RATK.	(M. H. Chang et al., 2017)
2	TAM	28	Attitude toward Use	Attitude toward Use	3	I like to use the GaaS RATK.	(M. H. Chang et al., 2017)
3	USE	17	Attitude toward Use	Attitude toward Use	4	As a gamer I like to use the GaaS RATK.	(M. H. Chang et al., 2017)
4	USE	29	Attitude toward Use	Attitude toward Use	5	The GaaS RATK is pleasant to use	(M. H. Chang et al., 2017)
5	SUS	7	Effectiveness	Ease of Learning	6	I could imagine that most people could learn how to use the GaaS RATK very quickly.	(M. H. Chang et al., 2017)
6	SUS	10	Effectiveness	Ease of Learning	7	I needed to learn a lot of things before I could get going with the GaaS RATK.	(M. H. Chang et al., 2017)
7	TAM	12	Effectiveness	Ease of Learning	8	Learning to use the GaaS RATK is easy for me.	(M. H. Chang et al., 2017)
8	TAM	19	Effectiveness	Ease of Learning	10	I find it takes a lot of efforts to become skillful at using the GaaS RATK.	(M. H. Chang et al., 2017)
9	USE	23	Effectiveness	Ease of Learning	11	I quickly became skillful with the GaaS RATK.	(M. H. Chang et al., 2017)
10	SUS	3	Effectiveness	Ease of Use	12	I think the GaaS RATK is easy to use.	(M. H. Chang et al., 2017)
11	SUS	4	Effectiveness	Ease of Use	13	I think that I would need the support of a technical person to be able to use the GaaS RATK.	(M. H. Chang et al., 2017)
12	SUS	5	Effectiveness	Ease of Use	14	I found the various functions in the GaaS RATK were well integrated.	(M. H. Chang et al., 2017)
13	SUS	6	Effectiveness	Ease of Use	15	I think there is too much inconsistency in the GaaS RATK.	(M. H. Chang et al., 2017)
14	SUS	8	Effectiveness	Ease of Use	16	I find the GaaS RATK very cumbersome to use.	(M. H. Chang et al., 2017)
15	CSUQ	16	Effectiveness	User Interface Design	17	The user interface of the GaaS RATK is pleasant.	(M. H. Chang et al., 2017)
16	Usability	1	Effectiveness	User Interface Design	18	The user interface of the GaaS RATK is confusing.	(M. H. Chang et al., 2017)
17	Usability	5	Effectiveness	User Interface Design	19	The GaaS RATK Menus were easy to use and navigate.	(M. H. Chang et al., 2017)
18	Usability	7	Effectiveness	User Interface Design	20	There are only a few steps to get the optimal settings for the GaaS RATK.	(M. H. Chang et al., 2017)
19	Usability	11	Effectiveness	User Interface Design	21	The logical design of the GaaS RATK is good	(M. H. Chang et al., 2017)
20	USE	11	Effectiveness	User Interface Design	22	The GaaS RATK is user friendly.	(M. H. Chang et al., 2017)
21	CSUQ	10	Efficiency	Information	23	Whenever I make a mistake while using the GaaS RATK I recover quickly.	(M. H. Chang et al., 2017)
22	CSUQ	11	Efficiency	Information	24	The information provided by the GaaS RATK is clear.	(M. H. Chang et al., 2017)

23	CSUQ	12	Efficiency	Information	25	It is easy to find the information I needed.	(M. H. Chang et al., 2017)
24	CSUQ	13	Efficiency	Information	26	The information provided by the GaaS RATK is easy to understand.	(M. H. Chang et al., 2017)
25	USE	15	Efficiency	Information	28	I can use the GaaS RATK without written instructions.	(M. H. Chang et al., 2017)
26	TAM	1	Efficiency	Usefulness	30	The GaaS RATK makes it easy for me to choose configuration settings.	(M. H. Chang et al., 2017)
27	TAM	2	Efficiency	Usefulness	31	Using the GaaS RATK allows me to start playing GaaS games faster.	(M. H. Chang et al., 2017)
28	TAM		Efficiency	Usefulness	32	Using the GaaS RATK allows me to configure my games quickly.	(M. H. Chang et al., 2017)
29	TAM	3	Efficiency	Usefulness	33	The GaaS RATK enables me to run diagnostic tests easily.	(M. H. Chang et al., 2017)
30	TAM	6	Efficiency	Usefulness	34	Using the GaaS RATK improves my gaming performance.	(M. H. Chang et al., 2017)
31	SUS	1	Satisfaction	Behavioral Intention to Use	35	I would like to use the GaaS RATK frequently.	(M. H. Chang et al., 2017)
32	SUS	9	Satisfaction	Behavioral Intention to Use	36	I am very confident using the GaaS RATK.	(M. H. Chang et al., 2017)
33	TAM	24	Satisfaction	Behavioral Intention to Use	37	I plan to use the GaaS RATK in the future.	(M. H. Chang et al., 2017)
34	TAM	25	Satisfaction	Behavioral Intention to Use	38	Assuming that I have access to the GaaS RATK, I intend to use it.	(M. H. Chang et al., 2017)
35	TAM	29	Satisfaction	Behavioral Intention to Use	39	I intend to continue to use the GaaS RATK.	(M. H. Chang et al., 2017)
36	Usability	14	Satisfaction	Behavioral Intention to Use	40	I will recommend others to use the GaaS RATK.	(M. H. Chang et al., 2017)
37	CSUQ	18	Satisfaction	Expectation	41	This GaaS RATK has all the functions and capabilities I expect it to have.	(M. H. Chang et al., 2017)
38	TAM	31	Satisfaction	Expectation	42	I would use the GaaS RATK in the future	(M. H. Chang et al., 2017)
39	USE	7	Satisfaction	Expectation	43	The GaaS RATK meets my needs.	(M. H. Chang et al., 2017)
40	USE	26	Satisfaction	Expectation	44	The GaaS RATK works the way I want it to work.	(M. H. Chang et al., 2017)
41	CGAS	21	Cognition	Confidence	45	I am good at playing video games.	(M. Chang et al., 2014)
42	CGAS	28	Cognition	Confidence	46	Playing video games is easy for me.	(M. Chang et al., 2014)
43	CGAS	17	Cognition	Confidence	47	I understand and play video games well.	(M. Chang et al., 2014)
44	CGAS	29	Cognition	Confidence	48	I am skilled at playing video games.	(M. Chang et al., 2014)
45	CGAS	7	Cognition	Learning	49	I like taking courses that use computers	(M. Chang et al., 2014)
46	CGAS	10	Cognition	Learning	50	Using video games in school is a good way to learn.	(M. Chang et al., 2014)
47	CGAS	12	Cognition	Learning	51	Playing video games improves my eye and hand coordination.	(M. Chang et al., 2014)
48	CGAS	19	Cognition	Learning	52	Playing video games enhances my imagination.	(M. Chang et al., 2014)
49	CGAS	23	Affection	Liking	53	I like it when people talk about video games.	(M. Chang et al., 2014)
50	CGAS	3	Affection	Liking	54	I feel comfortable while playing video games.	(M. Chang et al., 2014)

51	CGAS	4	Affection	Liking	55	I am very interested in solving quests/questions/missions in video games.	(M. Chang et al., 2014)
52	CGAS	5	Affection	Liking	56	I always try to solve the current quest/question/mission in video games.	(M. Chang et al., 2014)
53	CGAS	6	Behavior	Leisure	57	Playing video games makes me happy.	(M. Chang et al., 2014)
54	CGAS	8	Behavior	Leisure	58	Playing video games is part of my life.	(M. Chang et al., 2014)
55	CGAS	16	Behavior	Leisure	59	When I have free time, I play video games.	(M. Chang et al., 2014)
56	CGAS	1	Behavior	Leisure	60	I talk about video games with my friends.	(M. Chang et al., 2014)
57	CGAS	5	Behavior	Leisure	61	I am not alone in a video game as I can make friends there.	(M. Chang et al., 2014)

Athabasca University
RESEARCH CENTRE

APPENDIX B – Certification of Ethical Approval

CERTIFICATION OF ETHICAL APPROVAL

The Athabasca University Research Ethics Board (AUREB) has reviewed and approved the research project noted below. The AUREB is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS) and Athabasca University Policy and Procedures.

Ethics File No.: **22777**

Principal Investigator:
Mr. Matthew Stavert, Graduate Student
Faculty of Science & Technology\Master of Science in Information Systems

Supervisor:
Dr. Maiga Chang (Supervisor)

Project Title:
'Gaming as a Service Research Assessment Toolkit'

Effective Date: November 15, 2017 **Expiry Date**: November 14, 2018

Restrictions:

Any modification or amendment to the approved research must be submitted to the AUREB for approval.

Ethical approval is valid *for a period of one year*. An annual request for renewal must be submitted and approved by the above expiry date if a project is ongoing beyond one year.

A Project Completion (Final) Report must be submitted when the research is complete *(i.e. all participant contact and data collection is concluded, no follow-up with participants is anticipated and findings have been made available/provided to participants (if applicable))* or the research is terminated.

Approved by: **Date:** November 15, 2017

Ali Akber-Dewan, Chair
School of Computing & Information Systems, Departmental Ethics Review Committee

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