The Future of Distributed Gaming: Technical Advantages and User-Centred Design


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Resumo

Há uma procura potencial por soluções multimédia interactivas em rede que permitam utilizar jogos de PC em set-top boxes, PDAs ou outros dispositivos móveis de baixo custo. O projecto Games@Large (G@L) tem desenvolvido uma solução que permitirá a acessibilidade ubíqua de meios interactivos em dispositivos com poucas capacidades tecnológicas. Este artigo descreve a estrutura do G@L e apresenta um estudo que compara a experiência de utilização do sistema de streaming 3D do G@L com uma solução de streaming de vídeo considerada "state-of-the-art". Os testadores jogaram três jogos usando o G@L ou o StreamMyGame™ e os relatórios por eles gerados sobre a qualidade gráfica dos jogos foram comparados. Dependendo do jogo, a qualidade da imagem do protocolo de streaming 3D do G@L foi percebida como sendo do mesmo nível ou significativamente melhor do que a solução de streaming de vídeo comparada. Estudos futuros permitirão explorar mais as vantagens e as possíveis limitações do sistema G@L numa escala mais alargada de jogos e de utilizadores.

Palavras-chave: Gaming-on-demand, Streaming, Design Centrado no Utilizador, Estrutura Games@Large

Abstract

There is a potential demand for networked interactive media solutions that enable the rendering of PC games on set-top boxes, PDAs or low-cost CE devices. The Games@Large (G@L) project has been developing such a solution that would enable pervasive accessibility of interactive media from low-end devices. This paper describes the G@L framework and presents an experiment comparing user experience of G@L 3D-grahics streaming with a state-of-the-art video streaming solution. Subjects played three games using either G@L or StreamMyGame and self-reports of the acceptability of game graphics were compared. Depending on the game, the image quality of the G@L 3D-streaming protocol was perceived as being as good as or significantly better than state-of-the-art video streaming. Future studies will further explore the advantages and possible limitations of the G@L system with a wider range of games and users.

Keywords: Gaming-on-demand, Streaming, User-Centred Design, Games@Large Framework

Games@Large
Introduction

Digital gaming has grown into a booming business. In 2007, computer game sales have tripled to $9.5 billion since 1996 in the USA (ESA, 2008) and reached 7.3 billion in Europe (Nielsen Interactive Entertainment, 2008). As early as 1998, Americans spent even more money on computer games than the amount they spent on cinema tickets (Dill, K.E. and Dill, J.C., 1998). Nearly all western children play digital games; in the UK for instance, nearly all 6-15 year-olds, and 82% of 16-24 year-olds, play digital games (Pratchett, 2005), with similar figures in the USA (Roberts, Foehr, and Ridout, 2005) and Canada (Entertainment Software Association Canada, 2008). However, digital games are also popular among other age groups; about a third of US parents play digital games too. In fact, the average game player in the USA is 35 years old and the percentage of elderly gamers (50+ years) increased from 9% in 1999 (ESA, 2005) to 26% in 2008 (ESA, 2008). Gaming could be considered one of the fastest growing means of entertainment for all age groups and digital gaming technology is changing faster than ever to suit customers’ needs and to stay ahead of the competition.

One of the latest advancements in gaming technology is games-on-demand (GoD) by means of cloud computing. Interest in such gaming-on-demand services, which enable users to stream or download full-featured electronic games to their personal computer (PC) or game console via the Internet, is strongest among game enthusiasts but has potential mass appeal. A recent survey (Cai, 2004) indicated that more than 50 percent of online game enthusiast households are interested in such a service from their broadband carriers. Aligned with such findings, telecom operators in general, and internet service providers (ISPs) in particular, already include online gaming over the broadband network as an important service feature of their video entertainment bundles. But the patterns of entertainment services and video game consumption are changing. Mobility and digital home entertainment appliances have generated the desire to play games not only in front of a home PC but everywhere inside the house and on the move. Several low-cost consumer electronics end-devices are already available at home: as a result of TV digitalization, set-top boxes (STBs) have entered the home and, as a new trend, mini-laptops are gaining popularity. Although these devices are capable of executing software, modern 3D computer games are too heavy for them (Jurgelionis et al., 2009). Running interactive content-rich multimedia applications such as video games requires high performance PC hardware or a dedicated gaming console (Nave et al., 2008).
There is a potential demand for networked interactive media solutions that enable the rendering of PC video games on set-top boxes, PDAs or low-cost consumer electronic devices without a significant price increase. The Games@Large (G@L) project (www.gamesatlarge.eu) has been developing such a solution that would enable pervasive accessibility of interactive media through low-end devices that rely on different platforms (architectures and operating systems), thus facilitating users to enjoy video games in various environments (e.g., home, hotel, internet café, elderly home) without the need to use high-end devices, such as consoles or PCs. A key aspect of this solution is streaming the output of computer games within a local area network from a central server to an end device. Depending on the capabilities of the end device, different streaming techniques may be used. The G@L project has investigated two different approaches to streaming: (i) video streaming of already rendered frames of the game and (ii) streaming of graphics commands for local rendering on the end device i.e. 3D graphics streaming (Eisert & Fechteler, 2007).

Overview of current gaming-on-demand systems

User uptake of gaming platforms and choice of console depend not just on hardware specifications and functionality but also games catalogues and online services. PC games are effectively tied to the desktop/laptop and console gaming is seen by many as expensive or for dedicated gamers only. The Wii has broadened the console user base but there remains a massive potential for mainstream gaming on TV given the right technology solution, content and services offerings and pricing. There are several established or forthcoming games-on-demand and games streaming solutions incorporating one or more of the following elements: downloading and execution of the game on local devices; streaming within a local network; streaming from remote servers. Advances in wireless home entertainment networks and connectivity – which stream content between devices within the home – present potential solutions for playing PC games on TV. Airgo Networks’ faster-than-wired True MIMO Media technology and Orb MyCasting are notable but do not allow streaming of games. StreamMyGame (Tenomichi Limited) streams any DirectX PC game running on a main PC to a wide range of lower-end devices in the home including PCs, notebooks, netbooks, UMPCs, other Linux devices and the PlayStation 3 (players use the Sixaxis Controller as usual). Users can also record their game play or broadcast games for spectators. StreamMyGame also enables games to be played remotely over broadband (and wireless, mobile and WiMAX) networks that have sufficient capacity, potentially supporting Pay-for-Play services to existing PCs, PS3s and STBs.
Streaming video or graphics from remote servers to the PC or to the TV is the most common approach for games-on-demand. Examples of these services are: **Zeebo**, a Wireless 3G video game console based on low-cost hardware and BREW platform solutions which is targeting the huge developing markets of Brazil, Russia, India and China (BRIC); with the **EXEtender™** technology (Exent Technologies Ltd.) and **AWOMO** (Virgin Games), games are downloaded over broadband and executed locally on a PC – however, the user can start playing the game after just a small initial download with remaining data being continuously fetched during game play; **InstantAction** (GarageGames) uses a small plug-in and an initial download of the game to allow users to play 3D games in their web browser; **Xtremeplay** (NDS) enables high resolution streaming of computer games to set-top boxes; **t5 labs’** ‘Instant Gaming’ solution for set-top boxes via centralized servers hosted by cable TV or IPTV operators; **OTOY/AMD’s** Fusion Rendering platform offers film-quality graphics games to any internet-enabled device – computer, set-top box or even iPhone; **G-Cluster** also offers compression of game content and its streaming as MPEG over the IP network to the IP-STB.; finally, broadband games-on-demand service **OnLive** will use video streaming and compression technologies for gaming on PC or Mac without downloads and their ‘micro-console’ device will also allow gaming on TV.

**Games@Large Framework**

The G@L framework (Tzruya, Shani, Bellotti, and Jurgelionis, 2006) consists of several components. First, a Windows PC Local Processing Server (LPS) runs games from the Local Storage Server (LSS) and streams them to clients. It is responsible for launching the game process after client-side invocation, managing its performance, allocating computing resources, filing system and I/O activities, and capturing the game graphics commands or already rendered frame buffer for video encoding, as well as managing execution of multiple games and streaming audio. The LPS is further responsible for receiving the game controller commands from the end device and injecting them into the game process.

Second, the graphics streaming protocol is used for streaming 3D commands to end devices allowing lower performance devices such as interactive TV set-top boxes (STBs) to present high performance 3D applications such as games without the need to actually execute the games locally. The 3D streaming and remote rendering system developed for G@L are achieved through an architecture based on multiple encoding and transmission layers (Jurgelionis et al., 2009). The first layer is the graphics’ commands interception on the server and the last one is the rendering on the client. All the intermediate layers are
independent of any specific graphics Application Program Interface (API). This implies that the 3D streamed data are not specific to either DirectX or OpenGL but abstract higher-level concepts common to all 3D graphics (Jurgelionis et al., 2009). The 3D graphic streaming approach cannot be used for several mobile devices that lack the hardware capability for accelerated rendering and cannot render the images locally for displaying. For such cases, the Video streaming scenario is applied, exploiting H.264 (ISO, 2003) for low-delay video encoding.

Third, the network connection to the game client can be either wired or wireless. G@L wireless platform relies on the IEEE 802.11 standard family (IEEE, 1999). Currently, the mostly used WLAN technology is IEEE 802.11g that can, in good conditions, provide the bandwidth needed for four simultaneous game sessions (Jurgelionis et al., 2009). Priority-based QoS can be supported in IEEE WLANs with the Wi-Fi Multimedia (WMM) extensions (Jurgelionis et al., 2009), (Wi-Fi Alliance Technical Committee, 2004) specified by the Wi-Fi Alliance.

Additionally, the client module, running on a Windows/Linux PC or notebook or WinCE/Linux STB or a Linux-based handheld, receives the 3D graphics command stream and does the local rendering using the available capabilities (OpenGL or DirectX). For the video streaming approach, H.264 decoding must be supported, instead. The client is also responsible for capturing the controller (e.g. keyboard or gamepad) commands and transmitting them to the processing server (Nave et al., 2008).

**Technical advantages and challenges**

The state of the art gaming-on-demand systems offer a variety of possibilities, but are still unable to support high-level interactive media such as current successful game titles. Such applications now need costly ad-hoc adaptation and down-sizing. Using them seamlessly on a variety of devices would dramatically enlarge the market and increase the user options and experiences (e.g., allowing multi-player gaming in various environments such as homes, hotels, internet cafés, elderly houses).

The G@L approach enables the pervasive accessibility of interactive media from devices that feature different platforms (hardware and operating systems), thus facilitating users to enjoy video games in various distributed environments without the need for using a single device or operating system (Jurgelionis et al., 2009). Moreover, using a single PC to execute multiple games and stream them with a high visual quality to concurrently connected clients via a wireless or wired network supporting Quality of Service (QoS)
User-Centred Design – Advantages of G@L

The focus of G@L is to offer all age groups a low-cost platform for running computer games on various end-devices. For the success of such a platform it is highly important to gather an in-depth understanding about the needs, abilities, and concerns of potential users from different age groups and backgrounds. A considerable number of user-centred studies have already been performed within the G@L project to gather such an understanding (e.g., (Gajadhar, de Kort, and IJsselsteijn, in press), (IJsselsteijn, Nap, de Kort and Poels, 2007), (de Kort & IJsselsteijn, 2008)). In close cooperation with a multidisciplinary team of G@L designers, engineers, service providers, and applied cognitive psychologists, the acquired understanding was used to iteratively engineer a first working prototype. The next step is to perform user tests with the prototype focusing on the user acceptance of all components within the G@L system. The following experiment describes such a recent user test on the acceptance of the quality of G@L’s 3D streaming graphics. To benchmark the G@L prototype it was compared with a state-of-the-art video streaming service, ‘StreamMyGame’.

Method

Experimental Design & Procedure: A (2x3) fully counterbalanced mixed groups design was employed, with System (SMG vs. G@L) as the between subjects factor and Game as the within subjects factor. All participants played four sets of two randomly chosen games on one of the systems, and after each session they were asked to complete a self-report on the play experience. Each of the eight sessions took approximately 10 minutes, which included play time (5 min.), filling in the questionnaire (3 min.), and rest (2 min.). Eight play sessions were repeated on the following day changing the order of games. Afterwards they were debriefed, paid and thanked for participation. In total, participation over the two days lasted 3 hours and participants received a compensation of €30.

Participants & Apparatus: Sixty-three Dutch undergraduate and postgraduate students ($M_{Age} = 21.1; SD_{Age} = 2.3; 15$ female) participated in the experiment. Three different games were used from different game genres, namely, an action game (Sprill), a puzzle...
game (*Mahjong*), and a Third Person Shooter (*Total Overdose*), which were played (single player) on a 15.4” laptop.

*Measures:* A Mean Opinion Score (MOS) scale measured the appeal of graphics using the item “the graphics in the game were acceptable”.

**Results**

Linear Mixed Model Analysis (repeated measures) was performed on self-reports with System and Game as fixed factors, and subjects as random factor to allow inferences of a wider population. Figure 1 presents the mean graphics ratings for each of the games on the two systems.

Results showed a significant main effect for System (F(1,94.5) = 7.78; p<.01). The graphical quality of the Games at Large system was perceived significantly higher than the StreamMyGame system (MG@L = 3.8 (0.1); MSMG = 3.4 (0.1)). Furthermore, the analysis revealed a significant main effect for Game (F(2,216.7) = 20.18; p<.001). Additionally, an interaction effect was found for Game with System (F(2,217.7) = 5.06; p<.01). Further analysis (the same analysis, however per game) revealed that Mahjong was responsible for the significant main effect of System on perceived graphical quality (F(1,27.7) = 8.72; p<.01).

**Discussion**

Laboratory experiments have shown that the G@L system is capable of running video games of different genres, also including First Person Shooter games that are very popular and usually highly interactive and demanding for high end device performance. A G@L server can be hosted on a single PC and support multiple game executions and streaming with a high visual quality to concurrently connected clients via a wireless / wired network, in particular exploiting a QoS solution, which improves systems performance also in the presence of competing traffic (Jurgelionis et al., 2009). Furthermore, our technical
performance tests of the G@L system showed that the quality of a gaming experience is typically correlated with the game frame rate, bandwidth, resolution, and controller capabilities (e.g., some games cannot be controlled with a gamepad or a PDA keypad).

The user experiment showed that the image quality of the G@L 3D streaming protocol is perceived significantly higher compared to state-of-the-art video streaming. It is unclear which mechanisms are responsible for the significant difference in perceived image quality. Moreover, the lack of significance between the two systems for an action game and first person shooter (FPS) also remains unsolved. Differences may result from variation in graphics demand, in-game motion speed, or attentional focus per game. Future studies will further explore the advantages and possible limitations of the G@L system with a wide range of users and game types. What we learn from these studies will be used as input for the enhancement of the system, to be evaluated again with users and experts alike.

From the perspective of Service Providers, the achieved solution is already aligned with the need facing Telcos for bundle innovative offers of Services & Applications that could contribute to boost customer lifetime value and profitability (reduce the churn and increase the ARPU) (Dhar & Swamy, 2007). However it is the ubiquity of high speed broadband and the promise to move the capability of streaming videos games directly to the Internet that seems to open new and demanding business models that will foster the Games-on-demand market.

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