Design of intelligent network components to support multimedia on mobile thin clients

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I. Introduction

The thin client computing paradigm shifts computation and storage from the user device to the network. Applications are not executed on the user device but on remote servers. Through a remote display protocol, user input (e.g. keystrokes) is relayed to the remote application and graphical updates are delivered to the client for presentation on the device display. Only basic functionality is required at the client-side, resulting in "thin" devices that are lightweight and energy efficient. Consequently, the thin client concept is very appealing to mobile users.

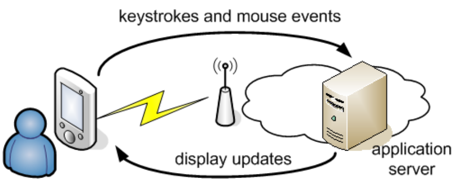

Figure 1. With a thin client, the user connects to a remote server generating display updates in response to user events.

The functionality of state-of-the-art mobile devices, such as PDA's or iPhones, is ever increasing. Every day, new types of applications are pushed on the devices. This comes at the cost of an increased battery energy drain. Thin client computing can bridge the gap between functionality demand and energy efficiency. However, mobile thin client computing can only break through if it can offer the same user experience as when the applications would run locally on the user's device. Even for the most demanding multimedia applications, the user is accustomed to a responsive user interface, smooth graphics and high-quality audio. Present remote display protocols cannot reach these high levels of user experience, because they are designed for office applications in stable network environments that provide sufficient bandwidth. It is the goal of this Ph.D. work to design a remote display protocol that supports multimedia applications, even in wireless environments with fluctuating bandwidth. Energy efficiency of this protocol is of key importance, as it will have to run on resource constrained mobile devices.

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II. Research challenges

Current remote display protocols are optimized for office applications, where display updates resulting from user input are infrequent and only involve a small part of the screen: e.g. a small menu must appear, or some typed characters must be presented. Multimedia applications generate images with fine-grained, complex color patterns and very little correlation between subsequent frames, while existing remote display protocols are tuned to handle images with large areas of solid color, few colors and little inter-frame difference. A first research goal of this Ph.D. work is the design of a remote display protocol that is able to present smooth multimedia graphics.

Thin client computing requires an intensive and continuous network communication between thin client and application server. If the network connection fails, the user cannot access his applications anymore. Network latency must be sufficiently low, so that the display update resulting from user interaction can be presented sufficiently fast. A second goal of this Ph.D. work is to enable thin client computing over wireless connections, that are characterized by unreliability, high delays and fluctuating bandwidth.

Last, the energy consumption required for the continuous network connection might undo the savings resulting from the shift of computation efforts to the network server. This is the third research challenge of this Ph.D. work.

III. Multimedia presentation

Applying existing remote display protocols, such as MicroSoft's RDP or Citrix' ICA, to present multimedia graphics on a thin client lead to high bandwidth requirements and irresponsive user interfaces. On the other hand, existing video codecs, such as H.264 or MPEG-2, can encode and transport this type of images in a bandwidth efficient manner, but they require more resources for decoding and more bandwidth for static applications than a "classic" remote display protocol. In the scope of this Ph.D. work, a hybrid protocol architecture is developed, that switches dynamically between a remote display protocol and video streaming. A decision algorithm is built, that analyzes the application graphics and decides on the optimal mode to relay the graphics to the client. In a second phase, this algorithm will take more input parameters into account, such as the remaining battery autonomy of the client or the current wireless network status. This cross-layer approach is presented in the next section.

IV. Cross-layer approach

The research challenges of enabling responsive thin client computing over a wireless communication link in an energy-efficient way, can be tackled by a cross-layer approach. The remote display protocol receives feedback from and provides information to the underlying layers of the network communication stack. For example, when the wireless link reports statistics on the current packet loss due to interference, the remote display protocol can lower the encoding quality to reduce the bandwidth. In the other direction, the remote display protocol can hint the wireless link layer on the transport priority of the data it generates. Transmission of low priority data can be scheduled in an energy-saving manner.

An intelligent reasoner is steering the different network stack layers. Monitoring information is analyzed, and if the user experience is unsatisfactory, an appropriate action will be executed. Some of the action mechanisms that will be implemented are caching of display updates to reduce network latency, detection of regions-of-interest in the display, prioritizing display updates to save bandwidth and optimize wireless link energy consumption.

V. Conclusion

Current remote display protocols are not suited to relay multimedia graphics over wireless links in an energy-efficient way. In the scope of this Ph.D. work, a cross-layer approach is adopted to enable wireless thin client computing and to minimize energy consumption. Through a hybrid remote display protocol and accompanying decision module, an optimal display update encoding is selected at all times.

References

[1] P. Simoens et al., "Design and implementation of a hybrid remote display protocol to optimize multimedia experience on thin client devices," in *Proceedings of Australasian Telecommunications and Network Applications Conference [accepted for publication]*, Adelaide, Australia, 2008.

[2] P. Simoens et al., "Design of an autonomic QoE reasoner for improving access network performance," in *Proceedings of International Conference on Autonomic and Autonomous Systems*, Gosier, Guadeloupe, 2008.

[3] D. De Winter, P. Simoens et al., "A hybrid thin-client protocol for multimedia streaming and interactive gaming applications," in *Proceedings of the 2006 International Workshop on Network and Operating Systems Support for Digital Audio and Video*, Newport, Rhode Island, 2006.