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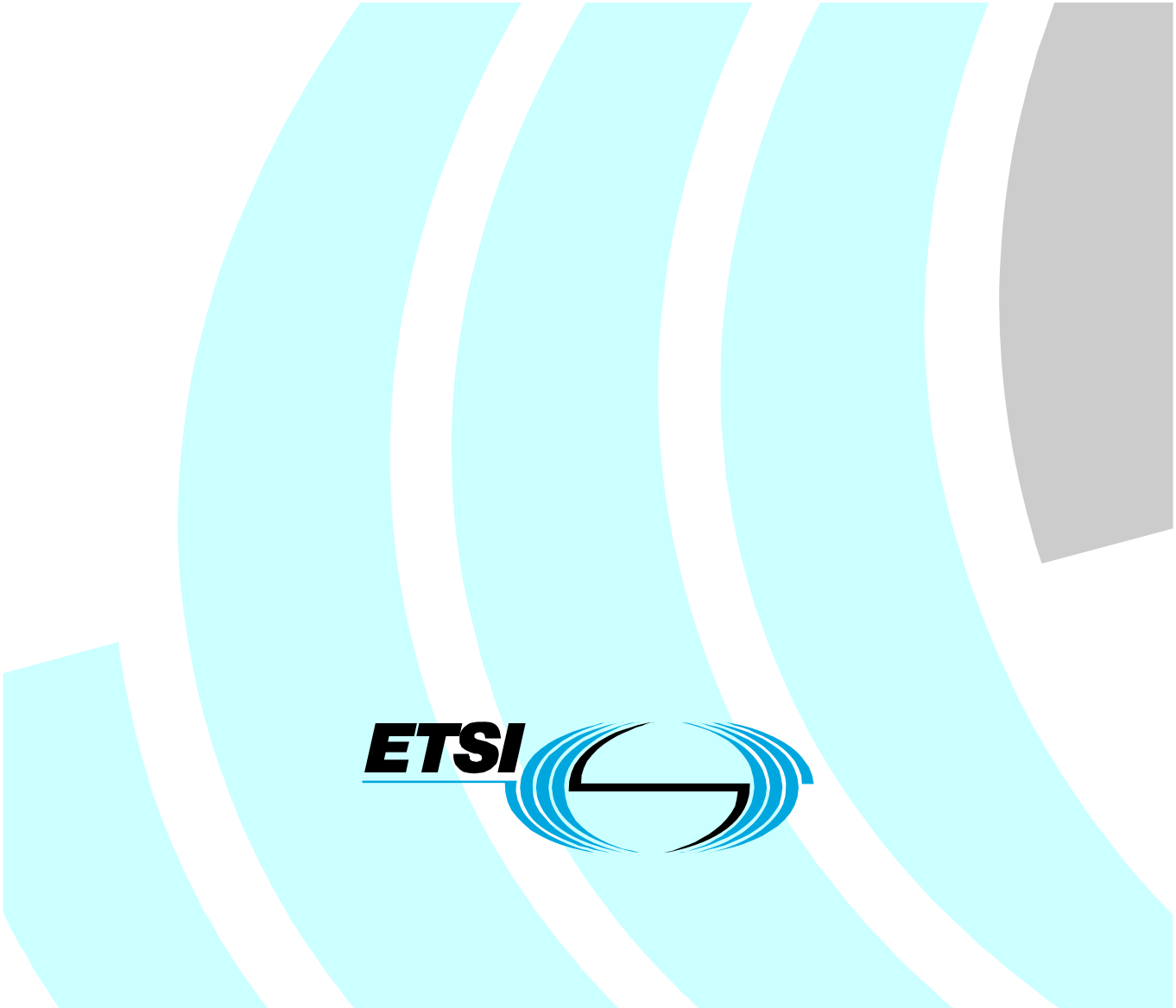
Group Specification

Mobile Thin Client (MTC); Use Cases and Requirements



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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Mobile Thin client Computing (MTC).

Introduction

The present document defines a set of consistent and complete requirements for a future mobile thin client system. An important consideration is that the mobile thin client system should work with the current available Internet and wireless communication network infrastructure (including the access network, the aggregation network and the core network). Requirements with respect to this network partitions are defined. Besides the network itself, additional infrastructural components are important for the mobile thin client system. Their function and the rationale for constructing the system out of these building blocks are described in the deliverable and requirements of the components themselves are defined. Namely those basic building blocks are the thin client server, the application image server, the data storage server, the thin client mobile device and the service management framework. The defined requirements are categorised into mandatory and optional.

The present document is a requirement document only, and does not describe technical solutions.

Motivated by the fact that the issues of security, detailed AAA implementation, seamless handover and the optimization of external resources (like application image server or data storage server) are amply addressed in other standardisation effort; the present document does not address these issues.

1 Scope

The present document is intended to define a set of consistent and complete requirements. Nevertheless, during the ongoing discussion, new requirements can come up. Hence, from the start on, the requirements (as well as the initial architecture) are intended to be relevant and adequate for future mobile thin client systems, while exhibiting the necessary flexibility to cope with new requirements.

The basic idea considered in mobile thin client system concerns nomadic users and addresses remote application access. User terminals considered range from laptops to smart phones, and applications should be delivered transparently (i.e. without changing the application code itself). This basic setting is further developed in the present document into more specific scenarios.

The following issues are excluded from the present document:

- Security;
- detailed implementations of AAA including billing mechanism;
- seamless handover;
- optimization of external resources, like application image server or data storage server.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] DGS MTC 009: "Mobile Thin Client (MTC); Architecture".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Niraj Tolia, David G. Andersen, M. Satyanarayanan "Quantifying Interactive User Experience on Thin Clients", IEEE Computer, Volume 39 - 3, pages 46-52, March 2006.

[i.2] Niraj Tolia, David G. Andersen, M. Satyanarayanan: "The Seductive Appeal of Thin Clients", February 2005.

[i.3] Pantel, L.: "On The Impact of Delay on Real-Time Multiplayer Games. International Workshop on Network and Operating System Support for Digital Audio and Video", 2002.

[i.4] Dick, M.: "Analysis of Factors Affecting Players" Performance and Perception in Multiplayer Games", Proceedings of 4th ACM SIGCOMM workshop on Network and system support for games, 2005.

[i.5] Deboosere, L., De Wachter, J., Simoens, P., De Turck, F., Dhoedt, B., and Demeester, P.: "Thin Client Computing Solutions in Low- and High-Motion Scenarios", in Proceedings of the Third international Conference on Networking and Services (June 19 - 25, 2007). ICNS. IEEE Computer Society, Washington, DC, 38.

[i.6] ITU Recommendation Y.1541 (February 2006): "Network performance objectives for IP-based services".

[i.7] "VirtualGL - Background" [online].

[i.8] A.F. Wattimena, et al.: "Predicting the perceived quality of a First Person Shooter: the Quake IV-model", 5th Workshop on Network & System Support for Games, Netgames 2006.

[i.9] C. Gutwin: 'The Effects of Network Delays on Group Work in Real-Time Groupware', Proc. 7th European Conf. Computer-Supported Cooperative Workshop, Kluwer, 2001, pp. 299-318.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

application image server (see note 2): repository for application images

NOTE 1: When a thin client server does not have a certain application installed locally, it gets it from an application server. This server does not run the applications but contains binary images and distributes these to thin client servers. However, the application image servers are external resources and not covered by the responsibility of the mobile thin client management framework.

NOTE 2: Distributed applications are supported as well. The client part is then transmitted to the thin client server when necessary. The thin client server runs the client part of the application and the server part would run on the original application server for that application.

application streaming: technology that virtualizes an application and splits it into blocks of executable code

NOTE: Only the required blocks of executable code are streamed from an application server to a client. This allows saving both disk space and time when executing a new application.

data storage server: repository for data a user uses (not for data about a user)

NOTE: Since the clients are to be thin, data storage is shifted into the network. This data will be accessed during mobile thin client sessions, or can be accessed independently: without the thin client provider. However, the application image servers are external resources and not covered by the responsibility of the mobile thin client management framework.

interaction delay or latency: in the present document, time between the generation of a user event (e.g. keystroke, pointer movement) and the resulting update, including presentation on the screen

NOTE: A substantial body of knowledge about the impact of interactive response times on user satisfaction and task productivity has been built up (see [i.1] and [i.2]). More information on delay can be found in Annex C of the present document.

mobile thin client session: dialogue or conversation between two or more entities

NOTE: Entities might be devices, software services or users. A session starts at a certain time, and ends at a later time. In terms of behavior, a session may be:

- a stateless session, meaning that the conversation consists of independent requests with responses.
- a stateful session, meaning that at least one of the end point parts should save information about the session history.

Regarding the OSI model, a session might be implemented as part of protocols and services at different layers:

- at the application layer, e.g. an interactive web session, a telnet remote login session.
- at the session layer, e.g. a Session Initiation Protocol (SIP) (Internet based phone calls).
- at the transport layer, e.g. a TCP connection or an established TCP socket.

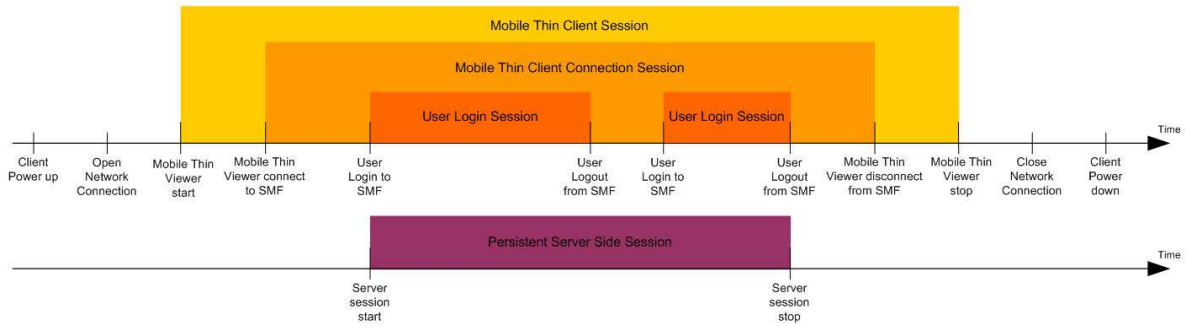


Figure 1: Visualisation of different definitions of "session" terms

packet delay: the delay a packet may experience on its transfer through the network

NOTE: This metric is particularly relevant for thin client environments, as every user input must be first transferred to the server before it can be processed. The packet delay has a huge impact on the user experience [i.6].

packet delay variation (jitter): the upper bound on the 1 - 103 quantile of the packet delay minus the minimum packet delay [i.6]

packet loss ratio: the upper bound on the packet loss probability

NOTE: In a thin client environment, packet losses might cause visual degradations or the loss of user events, leading to an unresponsive user interface [i.6].

session migration: situation or context when a given session shifts from one serve to another server

session mobility: situation or context when a given session shifts on a seamless way from device to device

throughput: the mean bit rate, averaged over some time interval, observed at the application level [i.6]

3.2 Abbreviations

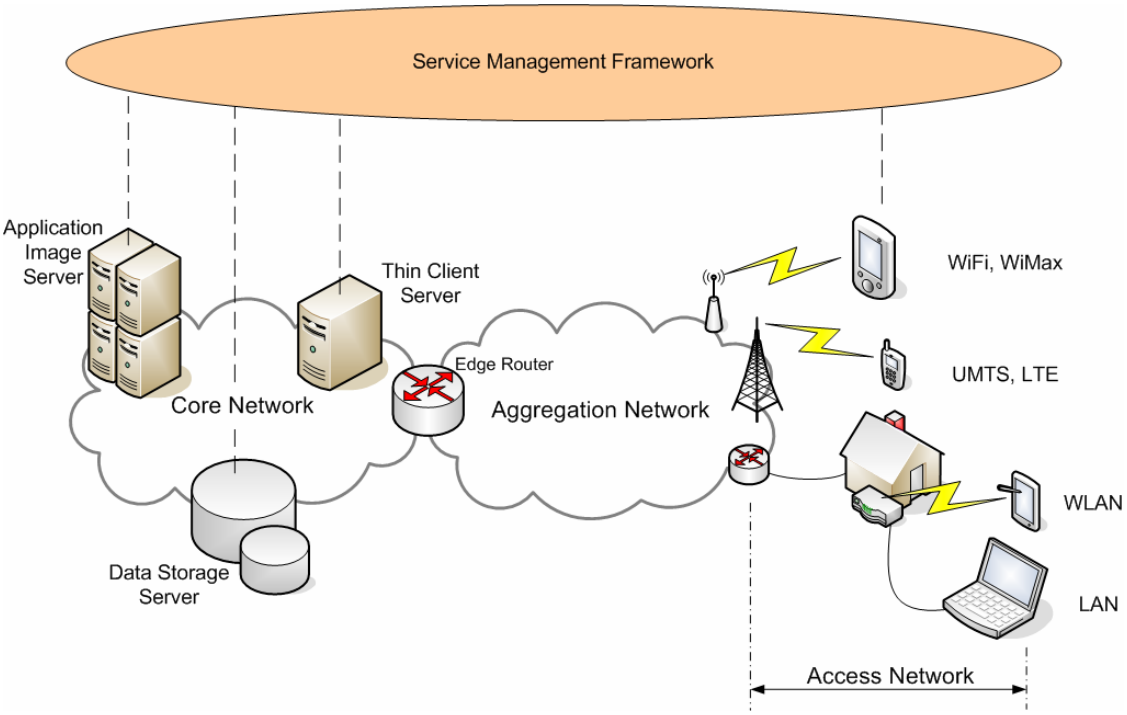
For the purposes of the present document, the following abbreviations apply:

AAA	Authentication, Authorization and Accounting
BER	Block Error Ratio
E2E	End to End
GPS	Global Positioning System
LTE	Long Term Evolution
MIBS	Management Iinformation Base
MTC	Mobil Thin Client
MTS	Mobil Thin Server
RDP	Remote Desktop Protocol
RFB	Remote Frame Buffer
SMF	Service Management Framework
SNMP	Simple Network Management Protocol

TC	Thin Client
TCS	Thin Client Service
UMTS	Universal Mobile Telecommunications System
VNC	Virtual Network Computing

4 System overview

The purpose of this clause is to provide a rough description of each component of the system in order to make the requirements comprehensive. This clause does not address a complete description of the system architecture. The system architecture will be treated in DGS MTC 009: "Mobile Thin Client (MTC), Architecture" [1].



NOTE: This figure only shows an example of a network configuration but is not intended to suggest allocation of infrastructure. There could be more than one instance of all types and some could be aggregated into the same physical machine or spread over multiple machines.

Figure 2: Network configuration

The Mobile Thin Client solution should work with the current available internet and wireless communication network infrastructure. This network basically consists of three main parts: the access network, the aggregation network and the core network. The thin client architecture uses this division as a basis too, as shown in Figure 2. The components shown are briefly explained below:

1) Core Network: the central part of the network, supporting high bandwidths. It is built and controlled for fast and efficient switching of data streams.

2) Access Network: the part of the network between client and base station

3) Aggregation Network: the network between base station and edge router, interconnecting the access network and the core network. It is an inter-working architecture bundling traffic of different users and handling the mobility of devices as they move from on access network to another. The aggregation network is potentially managed by another organization than the one of the core network. The aggregation network may also include roaming network infrastructures. Multiple aggregation networks exist simultaneously.

Besides the network itself, Figure 2 presents the infrastructural components that constitute the mobile thin client system. Their function and the rationale for constructing the system out of these building blocks are described in this clause, other sections in this clause elaborate on the requirements of the components themselves.

1) Thin client server: It is a physical machine that runs the applications of the user session. It receives user input and returns graphical output.

2) Application image server (see note 1): a repository for application images. When a thin client server does not have a certain application installed locally, it gets it from an application server. This server does not run the applications but contains them and distributes them to thin client servers.

NOTE 1: Distributed applications are supported as well. The client part is then transmitted to the thin client server when necessary. The thin client server runs the client part of the application and the server part would run on the original application server for that application.

3) Data storage server: a repository for data a user uses (not for data about a user). Since the clients are to be thin, data storage is shifted into the network. This data will be accessed during mobile thin client sessions, or can be accessed independently: without the thin client provider.

4) Thin client device: the mobile device through which users consume the thin client services.

5) Service management framework: this framework manages the network and the services. When a user logs in to consume thin client services, the framework searches an appropriate thin client server to connect to. Some functions of the service management framework are resource management, application management, load balancing, resilience, session management and business support such as billing and logging. The framework also provides hooks for security mechanisms. An important aspect that is also covered by the service management framework is Authentication, Authorization and Accounting (AAA).

NOTE 2: The application provider, data storage provider and thin client provider may be separate network elements as this is likely to improve manageability. The possibility exists, however, that these functions are merged in a practical setting. Also: multiple instances of these components could exist for scalability.

A small step-by-step example might provide better insight into the functions of the presented components:

- A user turns on his mobile thin client device. Access to the Internet is acquired. The user starts the thin client environment, which connects to the service management framework over the network.

- The service management framework checks the credentials of the user. If they are correct, the framework connects the thin client device to a well chosen thin client server (well chosen for load balancing, short network path, subscription information, etc.). Setting up this connection happens through the network provider.

- In the thin client environment, the user starts an application. If this application is already installed at the thin client server, it is simply started on that server machine. Otherwise, the thin client server connects to the service management framework to be connected through to an application image server. The desired application is transferred from the application image server to the thin client server, where it gets installed and executed.

- The user input is sent over the network to this thin client server, which executes the application and handles the user input, and eventually returns the graphical output.

- The user stores the documents that have been generated by thin client applications. Therefore, the thin client server requests a connection to a data storage server from the service management framework. The user documents get stored in his personal space reserved on the data storage server.

- The user shuts down the thin client environment (running on the mobile device). This causes a trigger to the service management framework to close the user session on the thin client server. As a final step the network connections between the user and the thin client server and service management framework are closed.

4 Requirements

4.1 Thin client device requirements

4.1.1 High level requirements

4.1.1.1 Device capabilities

No	Requirement
1	Device capability information SHALL be made available to the thin client framework.

4.1.1.2 User Input Interfaces

No	Requirement
2	The mobile thin client framework SHOULD adapt to the Thin Client device user input interfaces (keyboards, pointing & clicking device, shortcuts…) to increase the range of supported applications.

4.1.1.3 Display

No	Requirement
3	Thin client device MAY switch between an embedded and external display. In consequence the mobile thin client framework MAY adapt to the different characteristics of the displays.

4.1.1.4 Power consumption

No	Requirement
4	The thin client device using thin client adaptive protocol SHOULD be energy efficient and be aware of the trade-off to quality and energy efficiency.
NOTE 1: Similar requirements should appear at the thin client system. The power consumption also results from an end-to-end optimization. NOTE 2: Power consumption is considered globally, including receiver consumption (dependent on the quantity of data received) and decoder consumption (depending on the type of the data, i.e. video or graphics).	

4.1.2 Hardware Requirements

4.1.2.1 Display

No	Requirement
5	The thin client device SHALL support an embedded display resolution of at least up to 800 x 600 pixels (at least screen size 3").
6	The thin client device MAY also support an external display resolution of at least up to 1 280 x 1 024 pixels (at least screen size 10").

4.1.2.2 Battery performance

No	Requirement description
7	The thin client device SHOULD provide information about the remaining capacity of the battery.

4.1.2.3 Wireless Communication Network

No	Requirement description
8	The thin client device SHALL support at least one wireless communication interface (e.g. WiFi, UMTS, WiMAX, LTE, Bluetooth…)

4.1.3 Software Requirements

4.1.3.1 System OS

No	Requirement description
9	The thin client device MUST have driver installed to interact with: • User input interfaces • Display(s) • Network interfaces/systems

4.1.3.2 Mobile Communication Stack

No	Requirement description
10	The targeted mobile thin client device SHALL support APIs for cross layer optimisation feature for bandwidth usage reduction, reduced power consumption, optimal user experience whatever the network conditions.

4.1.3.3 Resident applications

No	Requirement description
11	The thin client device SHALL support resident application in parallel to the thin client application (e.g. Voice/video call).

4.2 Protocol Suite

Thin client computing requires intensive communication between the device and the server infrastructure. This clause details all requirements for each layer of the network stack. The issues that would be relevant to this clause are security and seamless handovers.

4.2.1 End-to-end requirements

In thin client computing, the graphical user interface is (spatially) separated from the application logic. The network transports the graphical data of the application to the client and the user events, such as keystrokes and pointer movements, to the application.

4.2.2 Delay and jitter

No	Description
12	Class 1 MTC systems: Interaction delay target for applications running inside the mobile thin client framework SHALL be in average 150 ms
13	Class 2 MTC systems: Interaction delay target for applications running inside the thin client framework SHALL be in average 80 ms
No	**Description**
14	The maximum jitter SHALL be 20 % of interaction delay value

4.2.3 Guaranteed delivery

Since the thin client system will operate in a wireless environment, some packet loss will be inevitable.

No	Requirements
15	In-order delivery of user events SHALL be ensured

4.3 Server System / technology

4.3.1 Application Image Server

No	Requirements
16	Application image servers SHALL provide an image of the application including all specific dependencies
17	Application image servers SHOULD support application streaming to be able to run an application on a thin client server without downloading the entire image

4.3.2 Data Storage Server

No	Requirements
18	Data storage servers SHALL allow users to access their data from outside of a thin client session.

4.4 Service Management Framework

Functions needed to facilitate efficient service delivery will be integrated in a single management framework. Important functions to be provided are related to the user management, proper infrastructure management, as well as offering business support.

4.4.1 User Management

4.4.1.1 Categories of Users

It is distinguished between two kinds of users:

- Users are people using the mobile thin client system via their device (Smartphone, PDA, laptop, …).
- Back-office users are people, managing the system, e.g.:
  - Administrator are responsible for the status of the mobile thin client system
  - Manager are in charge of managing user account, user subscription …

No	Requirements
19	SMF SHALL consider the following types of users with dedicated access and permission rights and minimum set of attributes specified in table 2: • The Back-office users • The users of mobile thin client services

Registered users must be clearly identified in such a manner that they can be perfectly distinguished by one or more of their attributes. A list of the minimum users attributes is:

Table 2: Minimum set of user attributes

Attribute name	Description
name (First and last name)	The identity of the user
user identifier	A numerical identifier. Should be unique.
User address	Address of the user
Billing identifier	e.g. account number, …
User subscription	List of subscribed services

4.4.1.2 User authentication

No	Requirements
20	SMF SHALL support an authentication method

4.4.1.3 Logging Users activities

No	Requirements
21	SMF SHALL have different levels of logging • Production (see note 1) • Tuning (see note 2) • Debug (see note 3)
22	SMF SHALL log all information needed for billing, statistics, debugging
NOTE 1: The level of logging targeted here is the one that would allow to answer "high" level questions like "who performed what and when". this level of logging is typically meant for charging tools and helpdesk tools. NOTE 2: This level of logging is intended for statistic tools that may help in better tuning of the SMF. For instance, connection processing rates, per component processing time for a request, etc... NOTE 3: This level of "fine grained" logging might help in complex and abnormal failures. An example is when a SMF component needs to raise an exception. The component might "log" the "reason" of the exception before stopping.	

4.4.2 Infrastructure

No	Requirements
23	SMF SHALL have a view on the available resources in the system

4.4.2.1 Infrastructure management

4.4.2.1.1 Topology of infrastructure

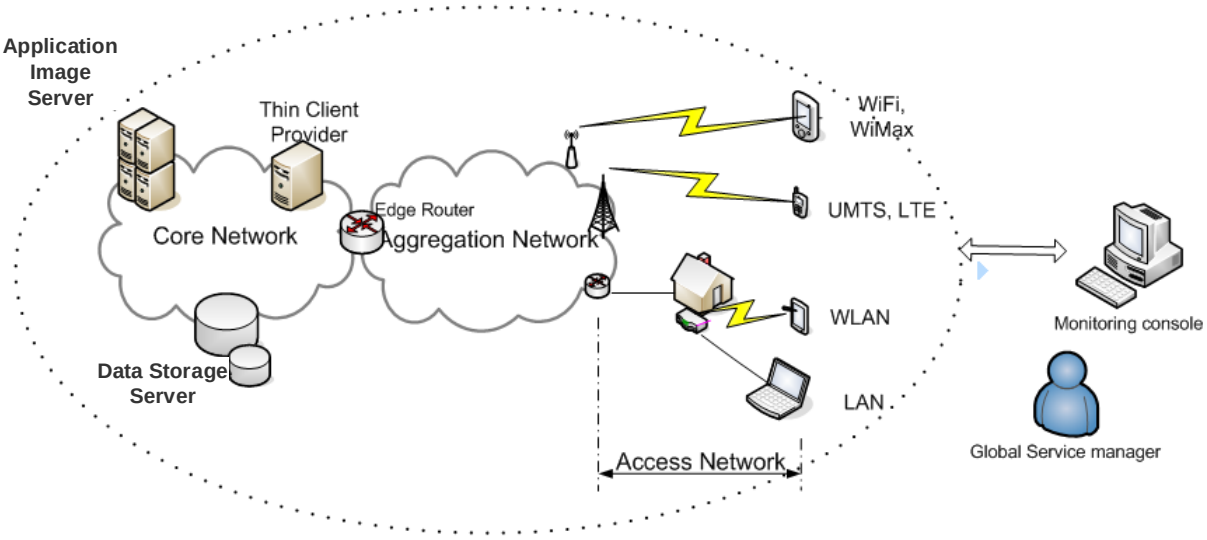


Figure 3: Overview of topology of infrastructure

Figure 3 gives an orientation for the following detailed classification of infrastructure management aspects.

4.4.2.1.2 Status of infrastructure

In the mobile thin client system, from an external point of view, the infrastructure is compound of the core network, the aggregation network and the access network. The core network hosts the application image servers, thin client servers and data storage servers. From the end-user point of view, all three parts of the infrastructure are seen as just one entity offering variant services.

Actually core network, aggregation network have their own management and monitoring systems so the present document only focuses on its own components and on the parts of the network not covered by existing management systems. Information in existing systems could be interesting for mobile thin client management system so we have to identify what is this information, where and how to get it.

4.4.2.1.2.1 General monitoring requirements

No	Requirements
24	Monitoring services SHALL support alert notification
25	Monitoring services SHALL support SNMP
26	Monitoring services SHALL define MIBS for standard monitoring tools

4.4.2.1.2.2 Network

As previously stated as a basic requirement in mobile thin client system, a typical network topology may include both wired and wireless network infrastructures. This requirement induces that network monitoring solution in mobile thin client system should encompass supervision of both technologies. In addition, network management should ensure to monitor all the infrastructure network components, starting from the end user device to the back-end servers.

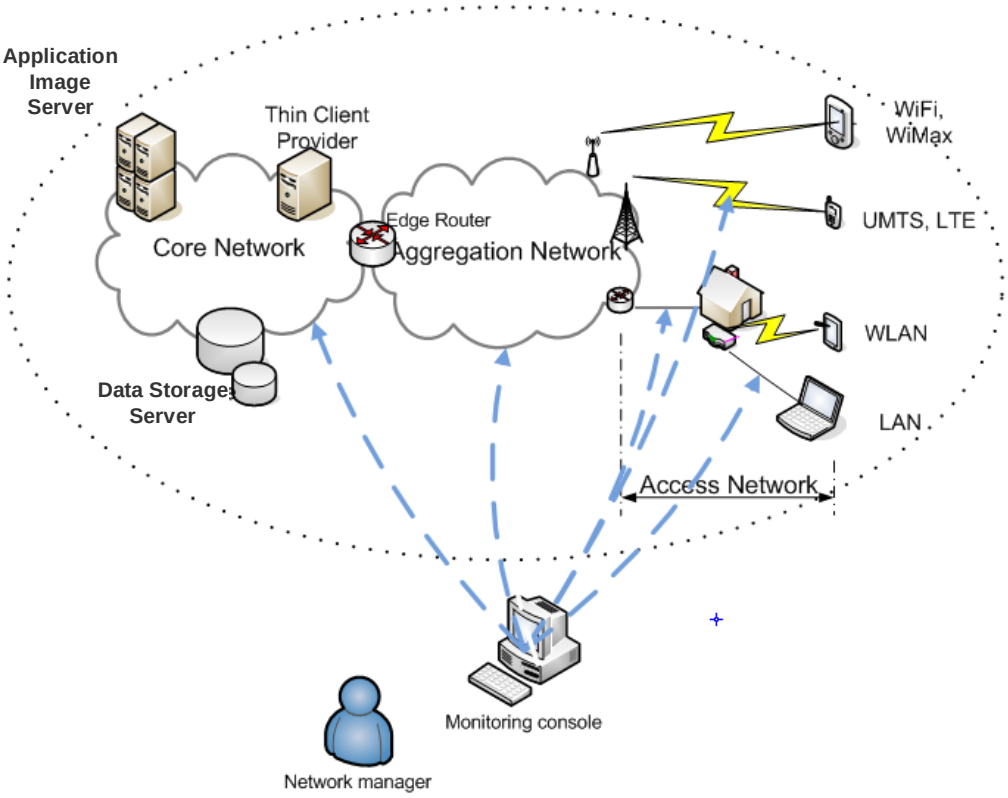


Figure 4: Network infrastructure monitoring

No	Requirements
27	Monitoring services SHALL monitor network availability, latency, total bandwidth and per user bandwidth usage.

4.4.2.1.2.3 TC server services

A TC server service is responsible for the user environment. The billing system could need some information about the user behaviour.

No	Requirements
28	Thin client connection and disconnection SHALL be monitored
29	User login and logout SHALL be monitored

No	Requirements
30	Monitoring services SHALL monitor CPU, memory, storage space of user data

4.4.2.1.2.3 Other services

No	Requirements
31	Energy suppliers MAY be monitored
32	User applications MAY be monitored

4.4.2.1.2.4 Hardware level-resource allocation / reservation

No	Description
33	The Thin client Service Management Framework guarantees the end-to-end requirements described in clause 4.2 by means of • Server Selection Algorithm (thin client server, application image server, data storage server) • Resource Reservation at the server (e.g. CPU cycles, MEM) • Migration when E2E requirements cannot be met by the current server • SMF having a load balancing component

4.4.2.1.3 Software Level - Configuration on each server

No	Requirements
34	Ports needed for SMF and TC protocol SHALL be configurable

4.4.2.1.4 Software Level - Installed applications on each server

No	Description
35	The Thin Client SMF SHALL know what applications are available at which location
36	The Thin Client SMF SHOULD support automatic application delivery from application image servers to thin client servers

4.4.2.1.5 Session Management

The SMF should allow for monitoring and logging all adequate information related to client connection and user login sessions.

Also, it is the responsibility of the SMF to allocate/reserve adequate resources needed for a correct session management. For more details, please refer to clause 4.4.2.1.2.4.

Since we need the SMF to support session persistence on the server, user login session shall be stateful. When a user reconnects, depending on the session nature (Virtual Machine or traditional Terminal Server session) and the status of the infrastructure (servers load, servers availability, network status, etc...), the SMF should either redirect the connection request to the old TC server where the previous session resides, or redirect it to an appropriate server and migrate the old session when possible. There are situations where the SMF should cope with device capabilities different from those attached to a previous session. In these cases two different options might be envisioned:

- The SMF is able to adapt the previous session to the capabilities of the new terminal.
- The SMF cannot adapt the old session to new settings, in this case the SMF may propose to the user the following possibilities:
  - stop the old session and start a new one with the new settings;
  - leave the old session and start a new one with the new settings (this is not desired since too many sessions per user might be left on servers, without real necessity);
  - keep the old session and disconnect the ongoing connection.

The exact definition of the attributes and behaviour of the previous different sessions will be specified in the architectural design and technical details.

No	Requirements
37	User login session SHALL be stateful (such that the same log-in can be used for different applications in the same session)
38	SMF SHALL support session persistence as defined above
39	SMF SHOULD support server session migration
40	SMF SHOULD support server session mobility
41	SMF SHOULD support terminal mobility
42	USER SHOULD be able to have more than one session active at a time
43	Session migration service SHALL allow control from the user
44	An authorized administrator SHOULD be able to allocate specific resources users or groups of users
45	An authorized administrator SHOULD be able to define user profiles (e.g. desktop appearance, …)

4.4.3 Business Support

4.4.3.1 Billing

No	Requirements
46	SMF charging and invoicing services SHALL be able to export charging and invoicing data in standard charging / invoicing formats
47	SMF SHOULD Support more than one billing system *
NOTE:	There is more than one billing system available, e.g. http://www.highdeal.com/product/billing-EN.shtml (commercial), http://www.jbilling.com/?q=node/424 (open source), http://www.capterra.com/utility-billing-software (software directory). It has to be decided and document in D2.2.

4.4.3.2 Reporting

No	Requirements
48	SMF reporting services SHALL be able to export data in standard format for Business Information tools
49	SMF reporting SHOULD Support more than one Business Information system

Annex A (informative): Examples of mobile thin client scenarios

A.1 Scenario 1: Bringing the hospital to the patient's home

Conveniently installed in his seat, Mr. GEPRACTI (general practitioner) was watching a theatre performance given by his son's school when his PA (personal assistant) rang: one of his patients had some troubles and need to be examined at once!

When arriving to patient's house, Mr. GEPRACTI wanted, as usual, to access all his records (notes, digitised X-rays, multi-dimensional scans, etc.) by simply connecting his PA to his office server. As the house was in a quite isolated place and as the mobile services were not provided there, Mr. GEPRACTI obtained the connection through the patient's wireless/fixed Internet connection. The images and short video footages were transmitted in lower resolution, adapted to his device characteristics and the available bandwidth. For clearer views (compulsory in some diagnosis issues) higher resolution images could be displayed by connecting the PA to the patient's TV-or HDTV-set.

During the examination, some patient's external symptoms determined him to get a second opinion from a medical specialist. Therefore he turned his PA in the high resolution camera mode and dialled the number of the specialist. The video was then stored on the office server of Mr. GEPRACTI for future recapitulation and transmitted to the specialist. As the examination showed nothing serious in the opinion of the specialist, they closed the call and Mr. GEPRACTI wrote down the prescription.

He was back to the son's performance just before the end … if only his son did not notice his absence!

A.2 Scenario 2: Getting in touch with Paris

For five years already, Mrs. and Mr. JATUBE (Just some American Tourists Uninformed but with Big Expectations) have wanted to visit Paris. Today their dream starts to become true: during his lunch break, Mr. JATUBE connected his mobile phone to the Internet and won an auction for a very low cost holiday, hotels and plane tickets from MiddleOfNoWhere to Paris included.

Of course, they are very happy but some concerns also arise. As the departure will be in about one week, they will have no time either for informing themselves about Paris main sights or for buying a good guide book. Moreover, they are perfectly aware that French is spoken down there!

Once in Paris, they understand that their concerns were unfounded. What a chance the city council exploits the virtual city application "Virtual Paris"!

On the first morning, they decided to visit Notre Dame and the Latin Quarter. On the streets, they immediately noticed some access points, where some decent people (just like them, with caps and sport shoes) queued-up. It was explained that these access points are a kind of light terminal, connected to the servers of the city hall and providing tourists with information about the neighbourhood: historical, architectural, shopping, etc. Moreover, it is free! An explicative notice also let them know that this service, with even more options, can be accessed by a simple cell phone.

Mr. JATUBE took out his phone and connected it to the servers of the city hall. It was a pleasant surprise: his cell phone sends to the servers the GPS coordinates and the starts displaying a virtual 3D view from the city. He starts testing the navigation function and searches for information about Notre Dame, his first target for today. On the homepage of the city of Paris they find the information about a game. The game is centred along a number of interesting points in the city, like a scavenger hunt. The target is to find the places and answer some questions; at the end, among the teams of the day a dinner is raffled off. When the client application detects that the JATUBEs are near one of these points (through a GPS receiver integrated into the device), they receive a mission with some instructions about that tourist hot spot. A 3D view of the city includes also a view on other teams. This provides possibilities for getting into contact with other visitors of Paris and for exchanging ideas about Paris. This 3D view is rendered on the server as the client does not have GPS information on other teams and lacks the processing power for local 3D rendering of complex scenes.

Due to the nature of the client devices, new media can be added to the 3D view, such as audio and video files or pictures.

A.3 Scenario 3: Keep scoring at school

Since his childhood, Bruno always has had difficulties in reaching the trade off between school and his true passion: soccer! This will no longer be the case now, with the advent of the thin mobile technologies!

Actually, he is following a course in video editing, in order to be able to produce small films for his favourite amateur soccer club. The course consists of a series of presentations with synchronized video fragments, serving as examples to illustrate the "dry theory". The presentations are streamed and are accompanied by a video stream in a small video window, presenting the tutor of the course. While travelling abroad to follow his club matches, Bruno takes the opportunity to catch up with his course. He's able to follow the course on the train and bus, and can even carry out his assignments.

The final exam is the production of a film on a chosen topic and it is just the next day after the Champions League final! So, once the match is over, Bruno connects through his thin client to his fan page of the soccer club hosted on his web server at home. He downloads the videos he shot during the match, opens in "remote mode" the video editing software and several older videos, because video editing is too resource intensive to run locally on his client. After finishing the work on the compilation of the "Our way to victory", he updates the web page.

After this editing, he is of course able to view the result, can discuss this online with his fellow students, and can listen to the tutor's advice. To ensure the work is OK for viewing in high resolution, he uses a head mounted display, connected to his thin client device.

Of course, one problem still disturbs Bruno … which is his tutor's favourite club?

A.4 Scenario 4: Mobile thin office

Professor Minerva KEAMS (Knows Everything About Mobile Services), a notorious researcher at MPI (Most Prestigious Institute), left her office in a hurry … she had no more than 45 minutes to catch the train to Nice where she was expected to give a talk next morning at 8:30.

Unfortunately, the last days were full of unexpected issues (from both research and administration) and she could not manage to have her presentation ready before leaving the office.

Once in the taxi, she took out her mobile phone and connected it to her VD (Virtual Desktop), thus resuming her work for the presentation. She also sent an email to Hermes MASIL (Most Appropriate Student In Lab) asking him to prepare a short demo with the integrated facilities of the new multimedia platform developed in her department. In addition she wants some slides prepared from MASIL to show the principle setup of the lab environment. This should be done in a collaborative session, which she will join when she is on the train to Nice. Note that fto be efficient she never included this platform in her VD: it requires strong servers for real time applications and, moreover, for a full multimedia application, a lot of codecs/players should be installed and continuously upgraded.

Once in the train, she turned off her mobile phone (silence, at least!) and got connected to her VD by the intelligent screen in the front of her seat (that's because the new AGV trains provide this connection at a quarter of the price asked by the mobile service provider). She starts a collaborative editing session with MASIL. With the advantage of the thin client, they are able to review in real time, the document live, without the burden of transferring the huge presentation file (> 50 Mbytes as it contains many animations and videos) over the network. Mrs. KEAMS is also able to vocally control the collaborative program, running on its usual personal office desktop.

So they were able to work very well for 5 hours and just before arriving in Nice she had a perfect presentation …

Annex B (informative): General aspects

Annex A describes some mobile thin client scenarios from which social, application and technical aspects are derived below.

B.1 Social aspects

Social aspects of the above described four mobile thin client scenarios are summarized in table B.1. The social aspects are grouped by "customer groups", "social interaction" and "business interaction".

Table B.1: Social aspects in mobile thin client scenario

Scenario	Customer group		Social interaction		Business interaction		
	Residential	Business	P2P	P2M	C2C	C2B	B2B
1		X	X	X			X
2	X			X		X	
3	X		(X)	X	(X)	X	
4		X	X	X	X	X	X

B.2 Application aspects

The major application aspects of the four mobile thin client scenarios are summarized in table B.2 and table B.3. The application aspects are separated in table B.2 in two groups, "application areas" and "special aspects". In table B.3 the connection types are summarized.

Table B.2: Application aspects in mobile thin client scenario

Scenario	Application area					Special aspect	
	Healthcare	Entertainment	Education	Office applications	Legacy (e.g. telephony)	Virtual Reality	Database access
1	X			X	X	X	X
2		X				X	
3		(X)	X				
4			X	X			

Table B.3: Connection types in mobile thin client scenario

Scenario	Connection types		
	Fixed	Wireless	Mobile *
1	X	X	
2		X	X
3		X	X
4		X	X
NOTE: Mobile technologies include any technology which is capable of providing connectivity at higher movement rates (> 150 km/h).			

B.3 Technical aspects

This clause gives an overview of the technical aspects of the mobile thin client scenarios, in terms of "mobility", "communication direction" and "client devices".

Table B.4: Technical aspects in mobile thin client scenario

Scenario	Mobility			Communication direction		Client device		
	User	Terminal	Server Session	Server-to-Client	Bi-directional	Energy efficiency	Client-side peripherals	Lightweight decoding
1		X		X	X	X	X	X
2	X			X		X		X
3	X		(X)	X		X		X
4		X	(X)	X	X	X		X

Annex C (informative): Information on parameters used in the present document

C.1 Delay:

The "trivial" interactions are the most challenging for thin clients. When a user presses a mouse button, he expects the pop-up menu to appear with no perceptible delay; in free-hand drawing he expects the on-screen curve to track his mouse movements without lag. The trivial interactions involve end-to-end communication (from user to application code and back to user), but involve negligible delay within the application. These interactions suffer the full queuing delay of the network, yet must meet the user's highest expectation of performance. This is in contrast, for example, to a click on a web link; in that case, the user is already expecting download delay.

A broad consensus has emerged on acceptable response times for trivial interactions:

- Response times below 150 ms are imperceptible to the user. This is therefore a good quantitative definition of "crisp response".
- In the range from 150 ms to 1s, users become increasingly aware of response time. They strongly prefer response times below 1 s.
- Above 1 s, users are unhappy. When forced, users are able to adapt to response times over 1 s. However, this is accompanied by frustration with the system and a drop in productivity.

For online multiplayer games, the delay requirements are slightly tighter. Several games of different categories have been investigated (role playing, first person shooter, car racing simulation…). A general consensus seems to be that (round-trip) delay is tolerable as long as it is below 80 ms to 100 ms (see [i.3], [i.4] and [i.8]).

It should be noted that negative experiences have much greater impact than positive experiences on judgment. Incidents of poor response times will be overweighted in users' memories. Even a few sluggish interactions in an otherwise acceptable interactive session may be sufficient to turn off a user.

The majority of the interaction delay is due to the network transmission delay. Some applications will run within the mobile thin client framework, thus mobile thin client system will have a higher level of control over the total end-to-end latency. Other applications run outside the mobile thin client framework (e.g. Google office suite), which means that we only have a limited impact on the transmission delay.

For the definition of the requirements on the interactivity delay, two parameters should be taken into account: the application type and the fact that the application logic is under the control of the mobile thin client system. Some limitations may occur from technical constraints (e.g. infrastructure and available resources).

C.2 Bandwidth

The upper bound on the bandwidth is determined by the bottleneck in the end-to-end path, shown in the network architecture of Figure 2. The wireless last link will probably be the main bottleneck. The end-to-end architecture should thus be designed to cope with typical bandwidths on the wireless infrastructures.

For each type of application, the thin client protocol should be as bandwidth efficient as possible while still offering the required QoE. As can be deduced from measurements on existing thin client protocols, the bandwidth requirements are dependent upon the application type. For static knowledge-worker applications (e.g. a text editor, a mail client), the average bandwidth for most well-known thin client protocols is given in figures C.1 and C.2, taken from [i.5]. In the office scenario, users execute a sequence of actions (e.g. typing, scrolling, inserting and resizing images etc.) in Open Office 2 Writer. The browser scenario consists of a sequence of websites visited. The websites includes pictures, JavaScript and/or flash animations and are viewed with Mozilla Firefox 2.0. Only one user was connected during the measurements. The client and server were connected by LAN. Specifications of the hardware and installed software are given in table C.1.

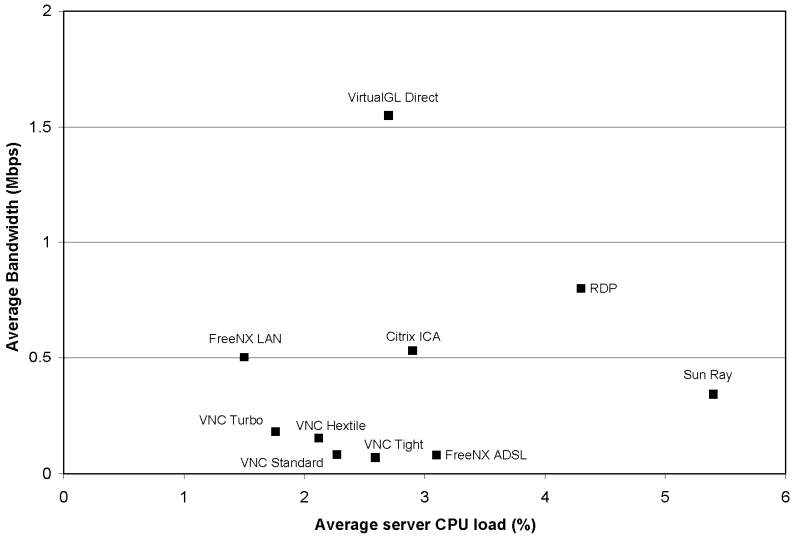


Figure C.1: Bandwidth for office scenario

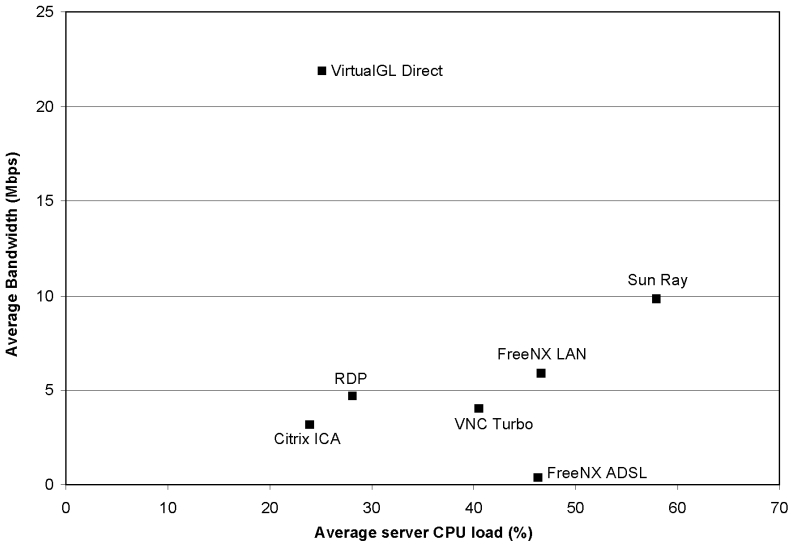


Figure C.2: Bandwidth for browsing scenario

Table C.1

	Thin client server	Thin client device
Processor	AMD Athlon 64 3500+	Intel Pentium 4 3,00 GHz
RAM	1 GB	1 GB
Linux OS	Kubuntu 6.10	Kubuntu 6.10
Linux kernel	2.6.17-10-386	2.6.17-10-386
Windows OS	Windows 2003 Server Release 2	Windows XP
Software	FreeNX Server 2.1.0-13 TurboVNC Server 0.3.2 TightVNC Server 1.2.9-19 Citrix Presentation Server 4.0 VirtualGL 2.0 Remote Desktop Protocol 5.0	FreeNX Client 2.1.0-9 TurboVNC Viewer 0.3.2 TightVNC Server 1.2.9-19 Citrix Client 9.2 VirtualGL 2.0 Remote Desktop Protocol 5.0 XviD codec

A mobile thin client system targets more demanding applications, such as 3D rendered images and online games. This type of applications is characterized by fine-grained, complex colour patterns and few correlations between subsequent frames. However, existing "classic" thin client protocols such as VNC/RFB or RDP are designed for static displays with large areas of solid colour, few colours and few inter-frame differences [i.7].

Attention should be paid when comparing with classic thin client protocols, as the required bandwidth is dependent on multiple factors: display size, resolution, colour depth… Also the image quality and client decoding load should be taken into account.

Some thin client protocols have different bandwidth-specific settings, thus exchanging compression for encoding load. The thin client image transmission architecture should be able to cope with changing bandwidth circumstances (during the session). The "reference" level for bandwidth drops is the "normal bandwidth", this is the bandwidth normally required for a certain application and requesting device under the best circumstances. The minimal fraction of this normal bandwidth that will be supported depends on the application type and the chosen radio bearer. For the most demanding applications, a drop to 20 % of the normal bandwidth will be targeted.

C.3 Jitter

The impact of jitter on thin client traffic is not yet studied in literature. However, in general, user studies have shown that jitter leads to a decrease in productivity and an increase in user errors [i.9]. The impact of jitter on video or audio quality is much better known. Different types of traffic will be transported by the mobile thin client framework. The tolerable amount of jitter is different for each type, so different dejitter strategies are necessary.

There may be a need for dynamic jitter configuration or adaptive buffering scheme (during a session). Firstly, higher Block Error Ratio (BER), at cellular access network radio level, would likely increase the packet retransmissions thereby leading to an increase of the delays (a typical 10 % BER is usually admit for best effort service in UMTS network). Then due to the mobility aspect, the mobile device may have poor or good level of radio strength, so the truly available bit rate may vary and would impact the streaming of video or audio as the delay may vary below or above the average jitter delay so the dejitter may requires reconfiguration.

Annex D (informative): Bibliography

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