Software

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  - + MHP
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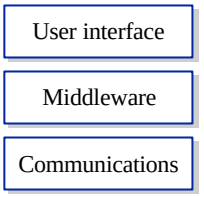
- Operating systems

Networked multimedia



- Network multimedia can be defined as multimedia applications and services, which are distribute into a network
- For example, www services, digital television, and WAP

Causes of multimedia

- Multimedia has continuous media elements, which have to be synchronized
- Media is usually transferred as streams
- Inside the stream, the samples (audio sample, video frame, etc.) are in order
- Media streams can be synchronized
  - + Internal synchronization: isochronous
  - + External synchronization: synchronous

Buffering of media streams

- It is impossible to synchronize media streams exactly
- Data transfer delay fluctuates, which causes jitter
- Human can detect even small fluctuation
- Fluctuation can be reduced with buffering
- Usually, buffering is required in several stages

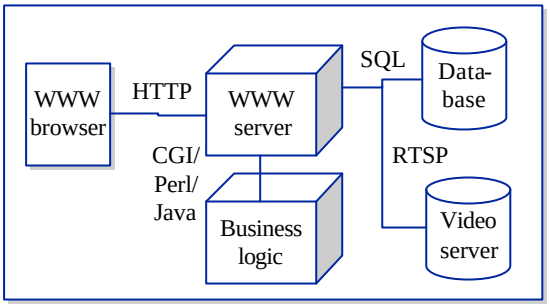
Programming

- There are two ways to implement distributed multimedia system:
  - + client / server
  - + distributed software
- Browser software architecture is typical example of client / server architecture
- Distributed software means usually distributing a object oriented software into a network

Browser based architecture

- Internet applications are based on client / server architecture
- WWW browser is a typical client program
- WWW server is a typical server
- There can also be other servers (database, video on demand, video conference, etc.)
- In addition infrastructure servers are needed (proxies, directories, etc.)

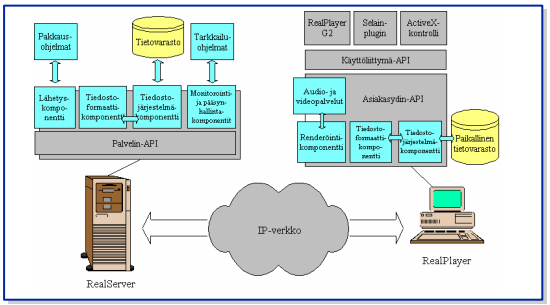
WWW architecture



RealSystem

- RealSystem is a typical example of client / server architecture
- The system can stream different media (audio, video, animations, etc.)
- The system is composed of development tools, intermediate servers, and client programs
- The basic version of the client software is free, but other software products are commercial

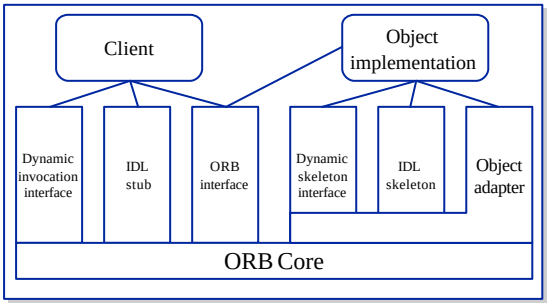
RealSystem architecture



Distributed software

- Object oriented software can easily be distributed to several computers
- Objects have to find each other somehow
  + directory service
- The method calls and replies of the objects have to be forwarded to the right computer
  + Object Request Broker (ORB)
- Commercial solutions are, e.g., OMG Corba, Microsoft DCOM & .NET, and Java RMI & Jini

Corba architecture



Components

- Client and object implementation talk via ORB
- The interfaces are defined with IDL (Interface Description Language)
- Normally, the calls are made to the static stub, which forwards the call via skeleton to the object
- The implementation can also be dynamic
- Object register with the help of the adapter

Software architecture implementation

- The software architecture can be implemented also on the system component level
- Multimedia affects both servers, network, and terminals
- Efficient implementation requires additional features and even full redesign of some components

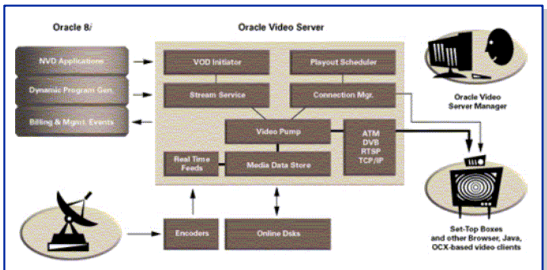
Servers

- The servers can be classified into transaction (www, data base) and streaming servers (video)
- Scalability is most important feature of transaction servers
  + if necessary, the task can be divided for several servers (replication)
- Most important feature of streaming servers is real-time support
  + in practice, this means real-time scheduling

Disk scheduling

- The hard disk usage of video-on-demand servers have to be designed carefully
- Usually, the disk seek time and space consumption is optimize
  + thus data retrieval is based on fairness
- Video-on-demand server has to keep buffers full
  + real-time scheduling algorithms
  + relative location of files

Oracle video server



Network

- Network has to support multimedia transfer:
  + Quality of Service (QoS)
  + real-time media streams
  + scalability
- Resources have to be reserved for multimedia traffic
  + ATM QoS
  + IP Integrated Services
  + IP Differentiated Services

Network (cont.)

- Network protocols have to support real-time media streams
  + e.g., IP Real-Time Protocol (RTP), Real-Time Control Protocol (RTCP), and Real-Time Streaming Protocol (RTSP)
- In addition, the network has to support several simultaneous users
  + e.g., IP Multicast

Terminals

- The biggest problem of terminals is limited resources:
  + processing power, memory, and communications
- Current operating systems support primarily graphical user interface
- Support for multimedia is more limited
- Real-time operating system support better multimedia

Multimedia processing steps

- Receiving of packets
- Network drivers
- IP/UDP protocol
- Real-time transfer protocols
- Codec
- Player
- Windowing system
- Audio, video, etc. drivers

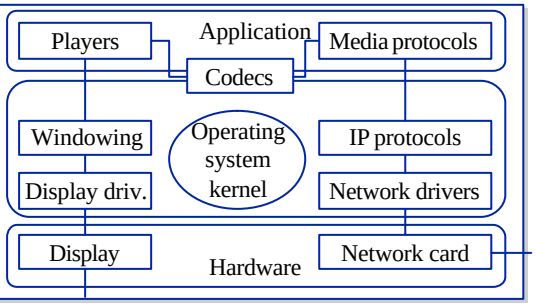
User interaction

- The terminal also has to track the user
  + keyboard
  + mouse
  + etc.
- The devices create interrupts
- The interrupts can easily jam with the network, etc. interrupts

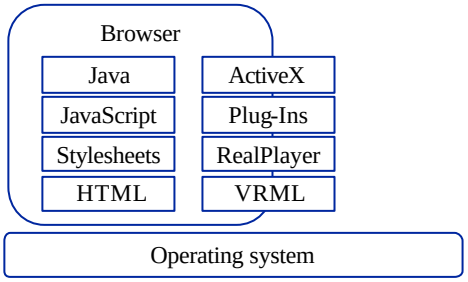
Terminal software architecture

- The terminal software architecture can be implemented with several ways
  + operating system + drivers + windowing
  + browser + plug-in players
  + Java
  + XML browser

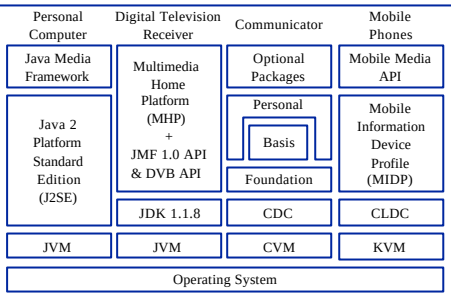
Operating system



Browser



Java



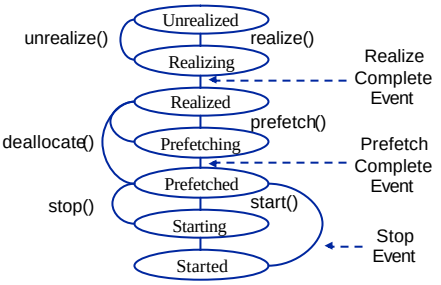
Device Configurations

- Connected Limited Device Configuration (CLDC)
  - + Slow processor (16/32 bit, 25 MHz)
  - + Little memory (min 192 KB)
- Connected Device Configuration (CDC)
  - + Faster processor (32 bit)
  - + More memory (min 2 MB)

Java Media Framework

- JMF allows use of multimedia in Java applications
- Real-time network protocols
- Multiplexing
- Codecs
- Players
- Effects
- Capture
- Control

JMF State Diagram



Java MIDP

- Mobile Information Device Profile (MIDP)
- Intended for small devices
  - + Mobile phones etc.
- Consists of Java Virtual Machine (JVM) and Application Programming Interfaces (API)
- Latest version 2.0

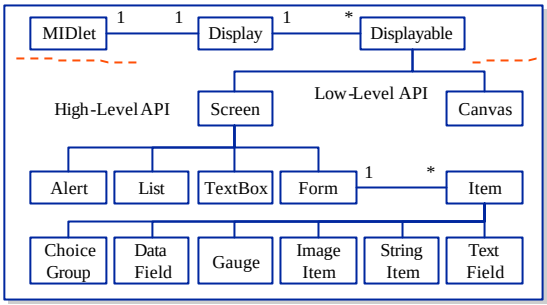
MIDP Requirements

- Minimum requirements are:
  - + Display 96x54, 1 bit (b/w)
  - + 256 KB memory for MIDP implementation
  - + 8 KB application memory
  - + Two directional network
  - + Audio

MIDP basic APIs

- Basic packets (java.lang & java.util)
- Network (javax.microedition.io)
- Application lifecycle (javax.microedition.midlet)
- Data storage (javax.microedition.rms)
- User interface (javax.microedition.lcdui & javax.microedition.lcdui.game)
- Certificates (javax.microedition.pki)
- Multimedia (java.microedition.media & javax.microedition.media.control)

MIDP User Interfaces



Extensions

- Java Bluetooth API (JSR-82)
- Java Wireless Messaging API (JSR-120)
- Java Mobile Media API (JSR-135)
- Nokia UI API

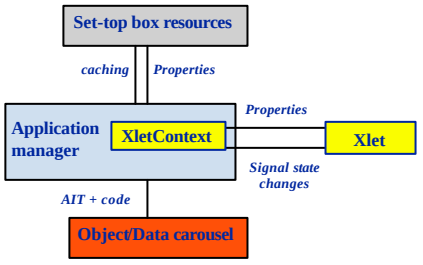
Mobile Multimedia API

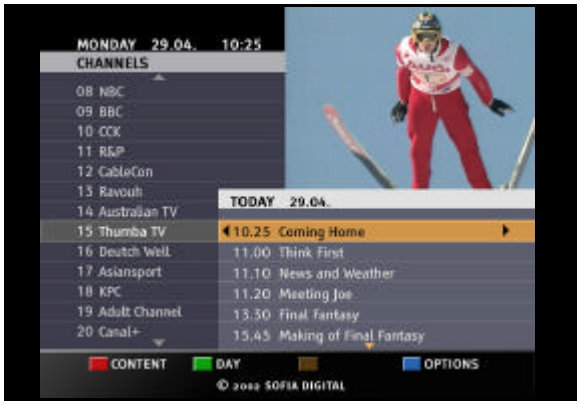
- Mobile Media (MMAPI) version 1.0
  + java.sun.com/products/mmapi
- Support for continuous media (e.g., audio, video) in MIDP
- Platform independent thin Java layer
- Not the same thing as JMF
- Optional package
- MIDP 2.0 includes only audio part of MMAPI

Multimedia Home Platform

- One example of Java environment is the Multimedia Home Platform (MHP) of digital television
- The environment is composed of Java, JMF, TV, net, etc. APIs
- Applications are called Xlets
- The Xlets are transmitted via broadcast network
- Data is transferred through so called data- and object carousels

Application Manager





XML

- Metalanguage for defining markup languages
  - + XML languages can be used either for presenting or processing of content
- Processing means, e.g., retrieval or filtering of XML data
- Presenting means presenting of XML content in different kinds of terminals
- Often, Cascading Style Sheets (CSS) and ECMAScript language are used in addition

Processing Languages

- eXtensible Stylesheet Language Transformations (XSLT) – XML data transformations
- XML Schema – Data model
- XPath – Element references

Presentation Languages

- XSL Formatting Objects (XSL FO) – Formatting
- eXtensible HyperText Markup Language (XHTML) – HTML 4.01 in XML format
- Synchronized Multimedia Integration Language (SMIL) – Synchronized multimedia language
- Scalable Vector Graphics (SVG) – Vector graphics
- X3D – 3D graphics
- VoiceXML – Voice control

Processing of XML data

- Parsing of XML file
- Parsing of XSL style sheet
- Transformation of XML according to XSL style sheet
- Document Object Model (DOM) data structure
- Execution of start-up scripts
- Building of presentation language layout model
- Rendering of presentation language
- Execution of event handler scripts

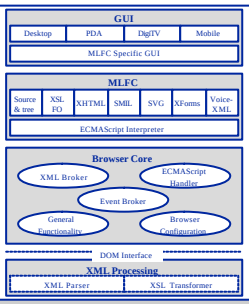
XML Components

- XML parser
- XSL transformer
- DOM interface
- ECMAScript interpreter
- XPath engine
- XML Schema engine
- CSS layout

X-Smiles History

- Development of X-Smiles started as student software project in 1998
- Later development work has continued in various research projects
  + GO
  + XML Devices
- Published as open source code in 2001
  + www.x-smiles.org

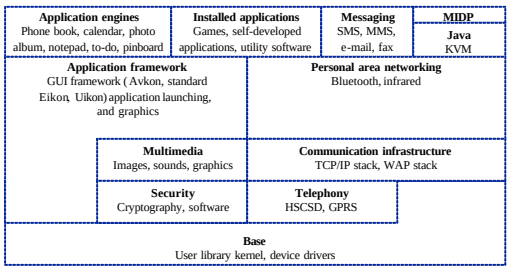
X-Smiles Architecture



Operating systems

- In current software architectures, operating system has very important role
- Most of the media processing is done by calling system software
- Application acts as coordinator
- Data copying between application and operating systems causes problems
- Operating systems are poor resource managers

Symbian OS



Real-time operating system

- **Small size:** extra features have been removed
- **Interrupt processing:** jamming prevented
- **Real-time scheduling:** time of task processing
- **Memory management:** shared memory
- **Message forwarding:** communication between different levels is fast
- **Resource reservation:** task will not be accepted, if resources are not available

Microkernel

- Operating system becomes more compact, if all “unnecessary” features are removed
  - + windowing, share file systems, etc.
- One solution is use so called Microkernel
  - + the kernel of the operating system is as small as possible and real-time
  - + other features are implemented as user processes
  - + the required system can be composed from different components

Embedded Linux

- Linux is an interesting alternative also in embedded devices
- Unnecessary features (e.g., X-Windows) can be removed so that memory consumption is reduced
- Implementation of real-time features in kernel is very difficult, but not always necessary
- For example, in set-top box hardware takes care of video and audio processing