13 Signaling Protocols for Multimedia Communication

Literature:

Stephan Rupp, Gerd Siegmund, Wolfgang Lautenschlager:
SIP – Multimediale Dienste im Internet, dpunkt.Verlag 2002

Outline

1.	Introduction and Motivation	
2.	Interactive Web Applications	Part I: Web Technologies for Interactive MM
3.	Web Programming with Java	
4.	Communities, the Web, and Multimedia	
5.	Digital Rights Management	Part II: Content-Oriented Base Technologies
6.	Cryptographic Techniques	
7.	Multimedia Content Description	
8.	Electronic Books and Magazines	Part III: Multimedia Distribution Services
9.	Multimedia Content Production and Management	
10.	Streaming Architectures	
11.	Web Radio, Web TV and IPTV	
12.	Multimedia Conferencing	Part IV: Conversational Multimedia Services
13.	Signaling Protocols for Multimedia Communication	
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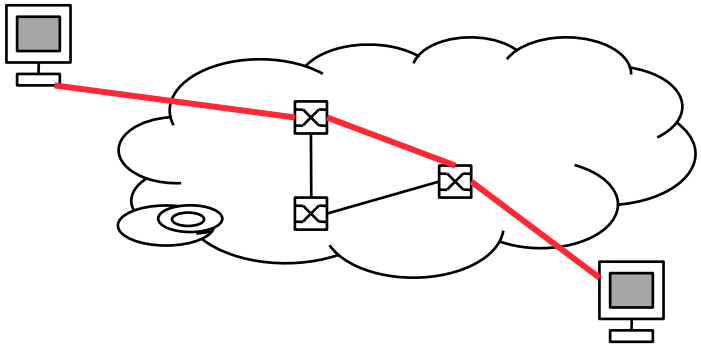
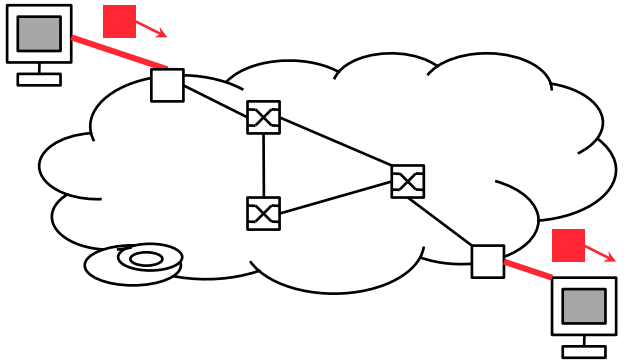
Communication networks

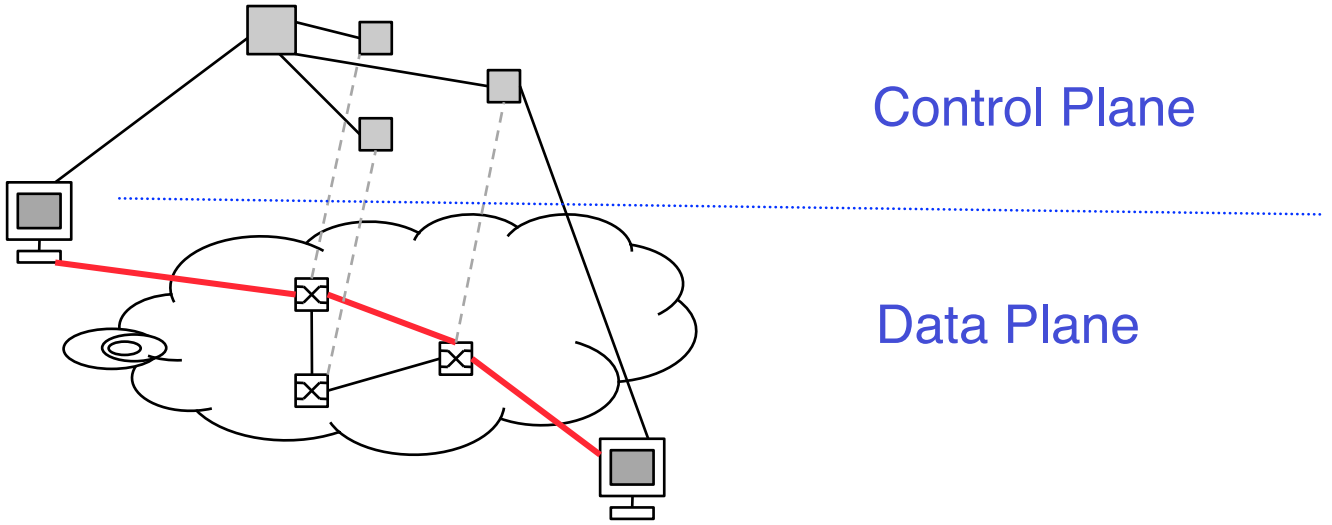
- Classification of communication networks:
  - Circuit-switched *(Leitungsvermittlung)*: Physical connection between communicating end systems (for limited duration)
    - » Traditional telephone networks
    - » *Virtual connections* in advanced digital networks (e.g. ATM)
  - Packet-switched *(Paketvermittlung)*: Transmission of packets to addressed end system
    - » Internet Protocol (IP)





Control Plane and Data Plane

- Classification of network mechanisms:
  - *Control Plane:* Mechanisms of the network to establish, modify and remove connections
  - *Data Plane:* Mechanisms of the network to transmit data over established connections
  - Strict separation of Control and Data planes in traditional telephone networks (e.g. ISDN)

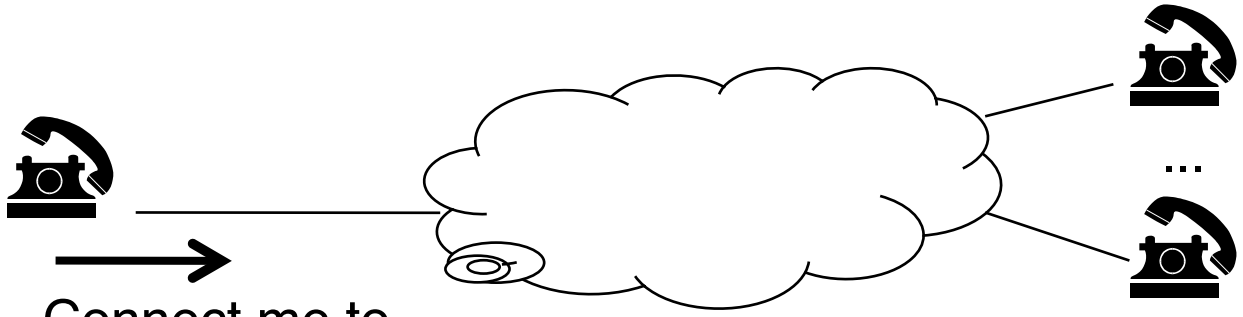


Signaling

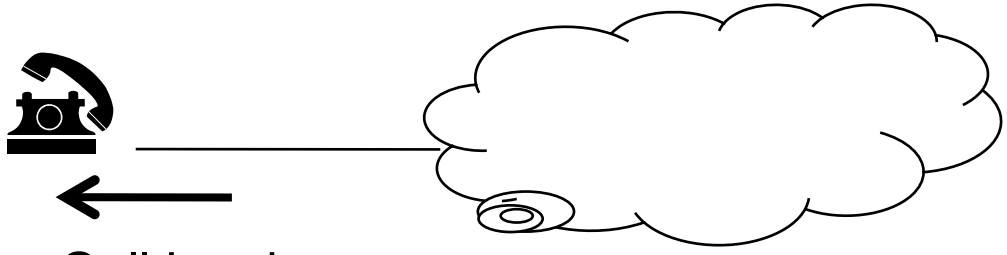
- *Signaling (Signalisierung, Zeichengabe)*
  originates from circuit-switched networks
- Signaling = Protocols of the Control Plane
  - User-to-Network Signaling: From end system to network interface
  - Network-to-Network Signaling: From one network node to another network node
  - End-to-End Signaling: From one end system to another end system

- Examples:
  - Call setup in ISDN
  - Call setup in ATM (Q.2931)
  - Resource reservation in IP networks (RSVP)

Signaling in Telephone Networks



Connect me to
number +49 2180 4650



Call has been
terminated

More complex signaling:

Add 3rd party to call
Forward incoming calls
Route calls according to
time and origin
...

Call Control and Bearer Control

- Signaling can be further separated in
  - *Call Control (Rufsteuerung):*
    - » Determining the partners to be connected
    - » Defining properties of connections
    - » Logical establishment of connection
  - *Bearer Control (Wegbereitstellung):*
    - » Determining the actual route in the network
    - » Establishment of connections in the network
- Call Control is relatively independent of network technology
- Bearer Control always depends heavily on the network technology

Signaling and the Internet – Why?

- *Convergence* of network technologies
  - To establish phone conversations over the Internet *(Voice over IP, VoIP)*
    - » Phone sets interconnected through the Internet
    - » Gateways between Internet and telephone networks:
      - calling a phone from a PC, using an iPod over WLAN like a phone, …
  - To support Bearer Control in the Internet
    - » E.g. by sophisticated resource management
    - » *Quality-of-Service* support
- On plain Internet:
  - Support of mobility
    - » User mobility: Forwarding to dynamically changing end system
    - » Terminal mobility: Forwarding traffic to end system in dynamically changing network location
    - » Service mobility: Support for services from foreign networks
  - To provide information on *status* of user or terminal (e.g. online/offline)

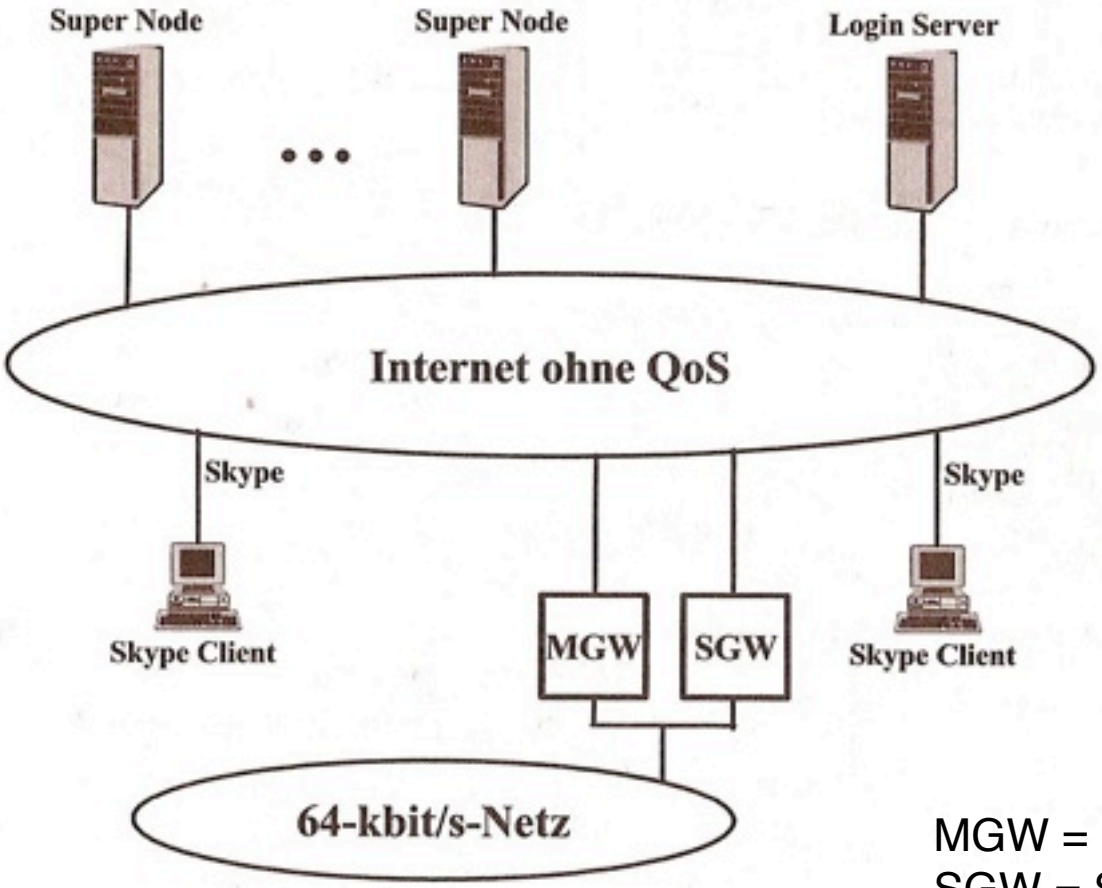
Signaling and the Internet – How?

- Internet is based on packet-switching
  - Classical Internet does not provide the concept of routes
  - Bearer control cannot be realized in plain Internet
- Signaling
  - Either restricted to Call Control
    - » Just informing the end systems of their current state
    - » SIP is essentially Call Control
  - Or involving advanced network features
    - » Support for Quality of Service
    - » E.g. by adjusting resources in routers
    - » E.g. driven by the RSVP resource reservation protocol

Network Architecture for Multimedia Conferences

- Session control:
  - Unit managing participants of a (conference) session
  - Management of involved connections
  - Monitoring of quality
- Signaling:
  - In particular call control:
    - » How does a participant set up/join/tear down a session?
  - Negotiation of capabilities among clients
  - Adaptation to network traffic situation
  - Advanced features (like multiple calls, intelligent forwarding)

Network Architecture Option 1: Skype Based



MGW = Media Gateway
SGW = Signaling Gateway

Bild 3.6: Skype für die Session-Steuerung

Trick/Weber

Skype Based Architecture

- Based on KaZaA peer-to-peer file sharing architecture
- Central *Login Server* for authentication
- Many *Super Nodes* form distributed database for user profiles
  - Powerful client computers with fixed address
- Steps in a Skype session:
  - User logs in (Login Server)
  - Client searches for Super Nodes and connects to a Super Node
  - Client gets address of communication partner from Super Node and establishes direct (peer-to-peer) communication link
  - Voice transmission: via UDP, adaptive between 24 and 128 kbit/s
    - » Predictive codecs: iSAC (LPC based), SILK (hybrid predictive/synth.)
  - Encryption of transmitted data
    - » Using AES 256 bit, key exchange through RSA
- Signaling and detailed architecture fully proprietary

Network Architecture Option 2: H.32X Based

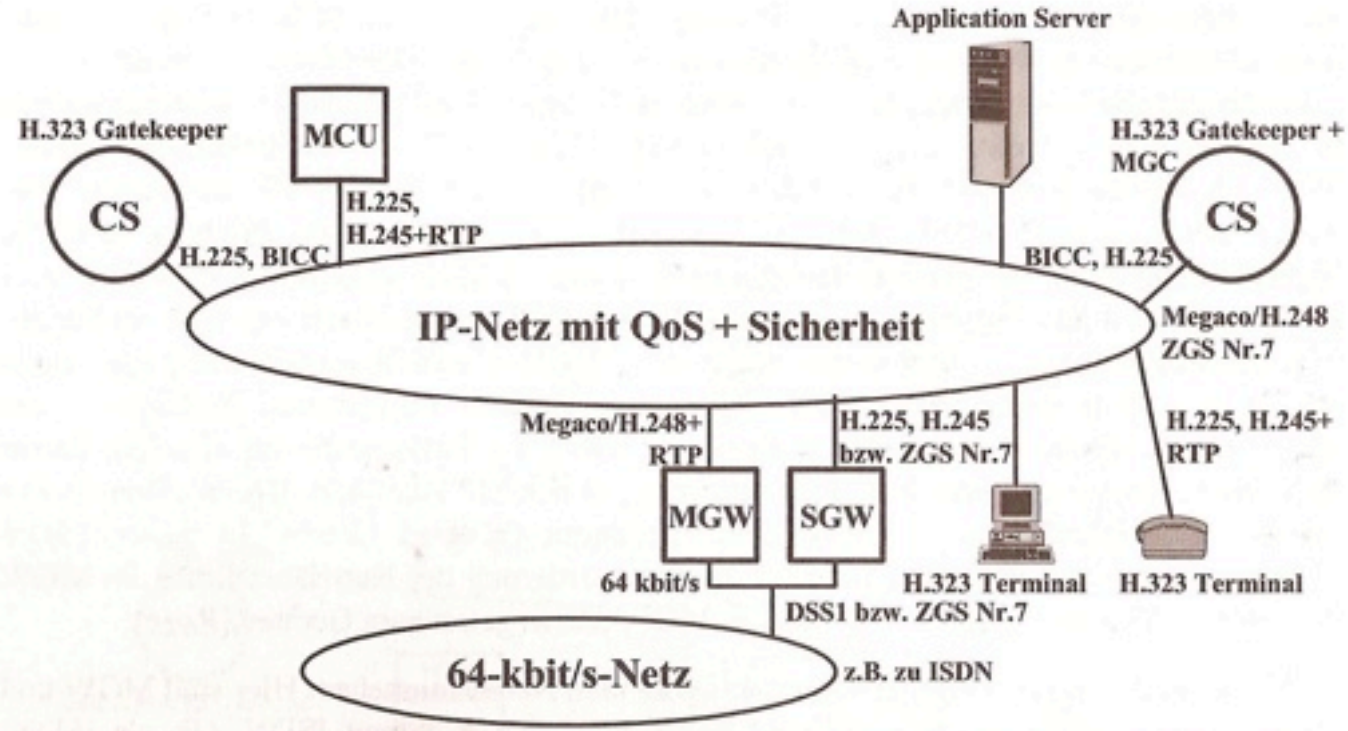


Bild 3.4: Protokolle und Netzarchitektur für Next Generation Networks mit H.323 für die Session-Steuerung

Trick/Weber

Network Architecture Option 3: SIP Based

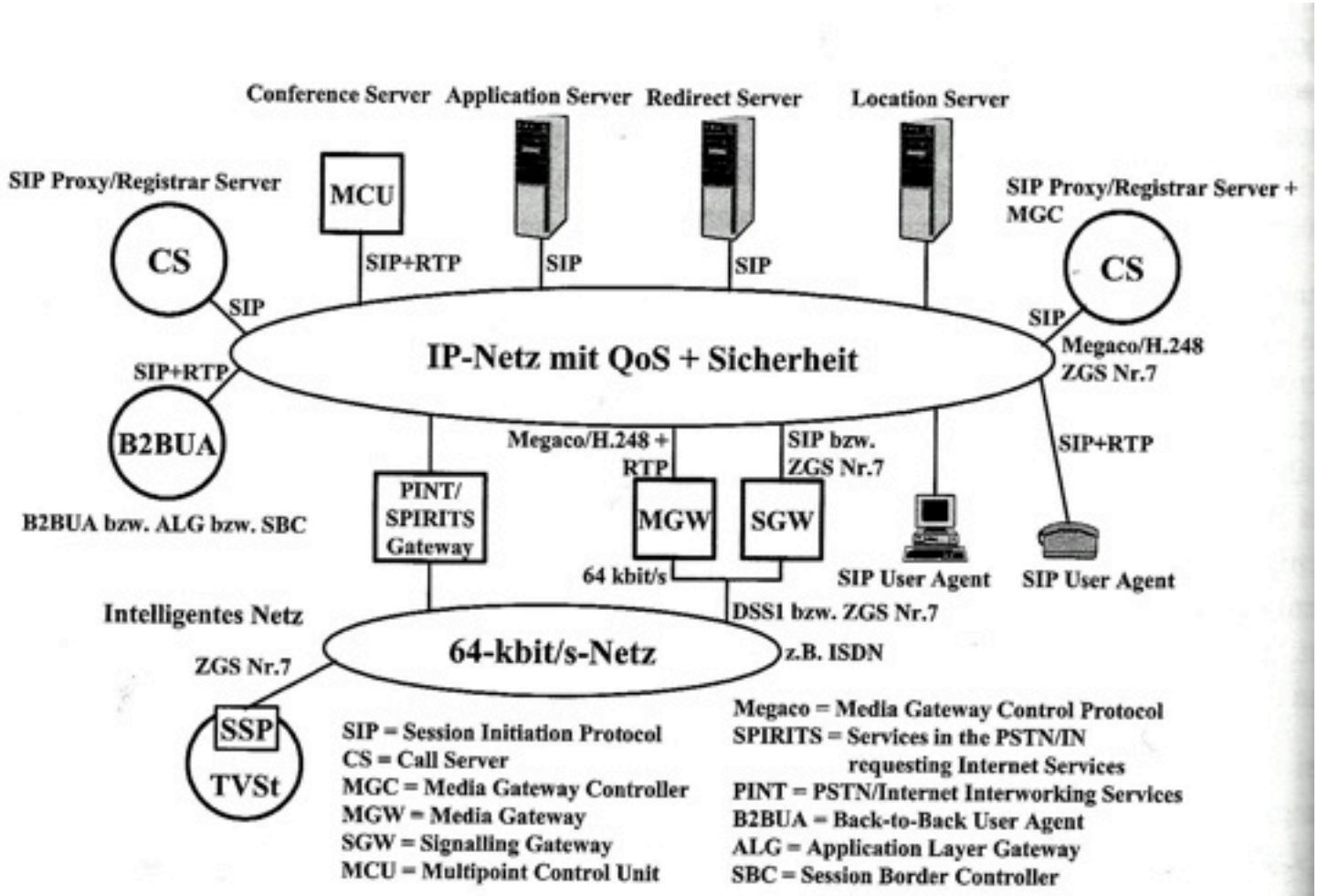


Bild 3.3: Protokolle und Netzarchitektur für Next Generation Networks mit SIP für die Session-Steuerung

Trick/Weber

13 Signaling Protocols for Multimedia Communication

13.1 Signaling and Sessions

13.2 SIP Basics

13.3 Signaling for Instant Messaging

Literature:

Stephan Rupp, Gerd Siegmund, Wolfgang Lautenschlager: SIP – Multimediale Dienste im Internet, dpunkt.Verlag 2002

Ulrich Trick, Frank Weber: SIP, TCP/IP und Telekommunikationsnetze, Oldenbourg, 4. Auflage 2009

SIP - The Context

- SIP = *Session Initiation Protocol*,
  standardized by IETF *(Internet Engineering Task Force)*
  - Signaling protocol independent of underlying network technology
  - Text-based client/server protocol, similar to HTTP
  - Covers broad range from traditional telephony to multimedia conferencing
  - Peer-to-peer style architecture:
    - » Client contains *User Agent* (UA) in client and server roles (UAC, UAS)
- Developed based on proposals by Mark Handley and Henning Schulzrinne, 1999
- Related other protocols:
  - SDP = *Session Description Protocol*
  - SAP = *Session Announcement Protocol*
  - SCCP = *Simple Conference Control Protocol*
  - RTSP = *Real Time Streaming Protocol*
  - RTP = *Real Time Transport Protocol*
- *MMUSIC = Multiparty Multimedia Session Control*

Main Features & Components of SIP

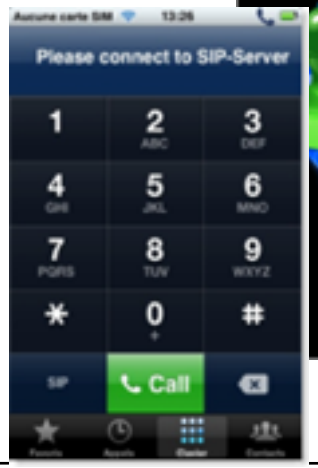
- SIP Proxy Servers for forwarding of control messages
  - Including “redirect” and “location” servers
- Support of user, terminal and service mobility
- Gateways to traditional networks (e.g. telephone networks)
  - Including services of the so-called “Intelligent Network” (IN), i.e. advanced network features
- Status observation for users and terminals (e.g. online/offline, busy/free)
- Service creation and execution tools
  - Call Processing Language CPL
  - XML-Scripts in SIP server
  - SIP-Java-Servlets

- In the following: Focus (first) on audio connections = “IP telephony”

SIP Terminals

- PCs, laptops, tablets, mobile phones, music players, ...
  - with SIP-enabled applications
  - with Internet access (e.g. WLAN)

- SIP version 2 (RFC 3261, 3262, 3263, 3264)
- SPCP with the Cisco Unified Communications 500 Series
- SIP proxy redundancy: dynamic via DNS SRV, A records
- Reregistration with primary SIP proxy server
- SIP support in NAT networks (including STUN)
- SIPFrag (RFC 3420)
- Secure (encrypted) calling via SRTP
- Codec name assignment
- Voice algorithms:
  - G.711 (A-law and μ-law)
  - G.726 (16/24/32/40 kbps)
  - G.729 A
  - G.722



Pictures: Cisco, BeyondTel, code.google.com/siphon

Addressing in SIP

- SIP supports various address formats including addresses based on phone numbers
  - ITU standard for international phone number format: E.164
- Email style addresses:

  `sip:Heinrich.Hussmann@ifi.lmu.de`
- IP-based addresses:

  `sip:hussmann@141.84.8.6`
- Phone number style addresses:

  `sip:+49-89-2180-4650@net2phone.com`
- Mapping of E.164 telephone numbers to IP domain names
  - +49-89-2180-4650 is mapped to domain name 0.5.6.4.0.8.1.2.9.8.9.4.E164.arpa
- IP-based addressing of terminals is a potential problem
  - Many large sites use NAT (network address translation)

SIP Servers

- Each SIP system can act as a SIP client *(User Agent Client, UAC)* or as a SIP server *(User Agent Server, UAS)*
- Functions of a SIP server:
  - Registration of SIP terminals
  - Registration of users including their profiles
  - Authentication, authorization and accounting (AAA)
  - Determination of end address
    (mapping of symbolic to current physical address)
  - Forwarding of requests
  - Call control (e.g. suspend and resume of connections)
  - Collecting and presenting information of user presence
  - Forwarding of QoS requests to network elements

SIP Messages

- Text-based peer-to-peer protocol
- Modelled after HTTP
  - *Header* contains connection parameters and service information
  - *Body* contains description of connection (using *Session Description Protocol* SDP)
- Requests:
  - From client (agent) to server (agent)
  - INVITE, BYE, OPTIONS, STATUS, CANCEL, ACK, REGISTER, …
- Responses:
  - Status information, e.g.
    - » Informational: 100 Trying, 180 Ringing, 181 Call is forwarded, …
    - » Success: 200 OK
    - » Redirection: 300 Multiple Choices, 301 Moved Permanently, …
    - » Client Error: 400 Bad Request, 404 Not Found, 486 Busy Here, …
    - » Server Error: 500 Internal Server Error, 504 Gateway Timeout, …

Call Setup by Three-Way Handshake

- Direct connection establishment between two SIP terminals (user agents)

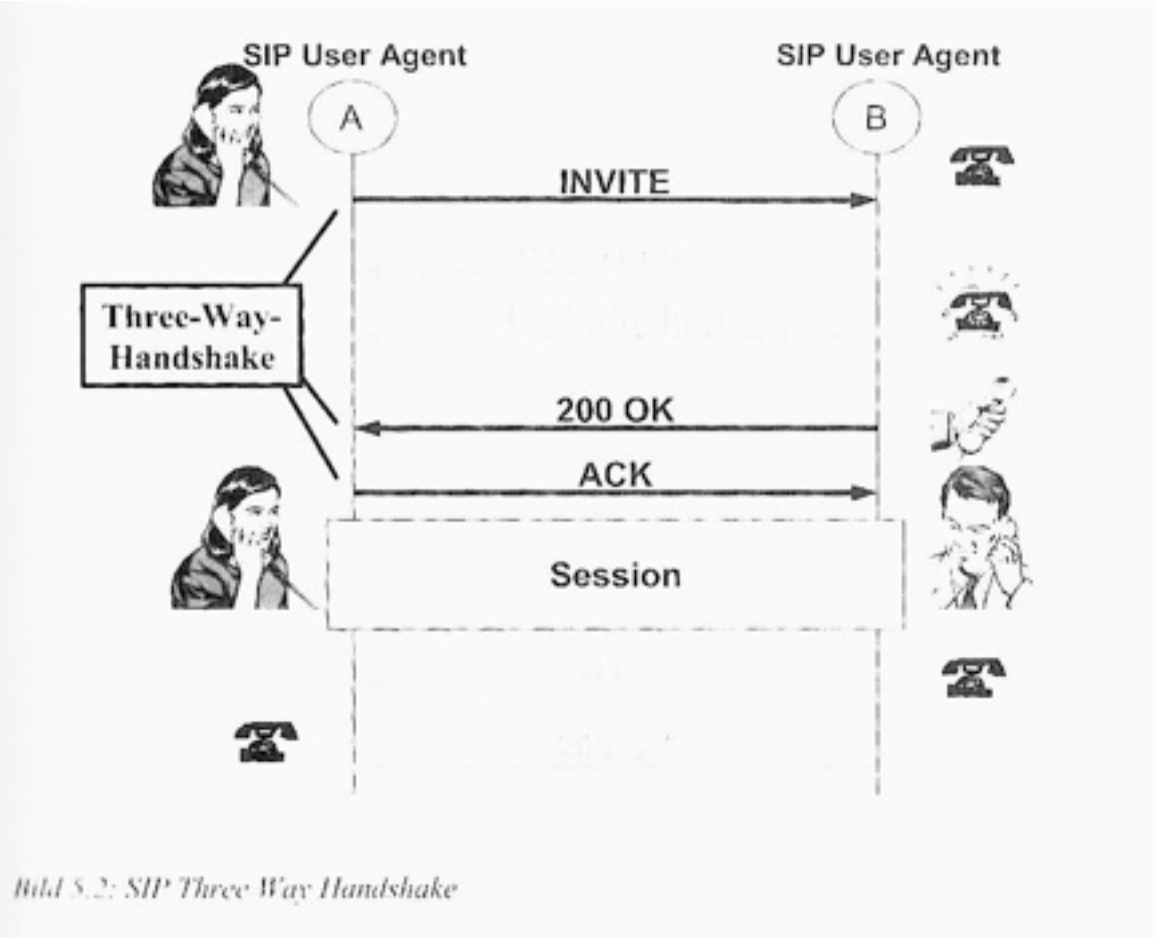


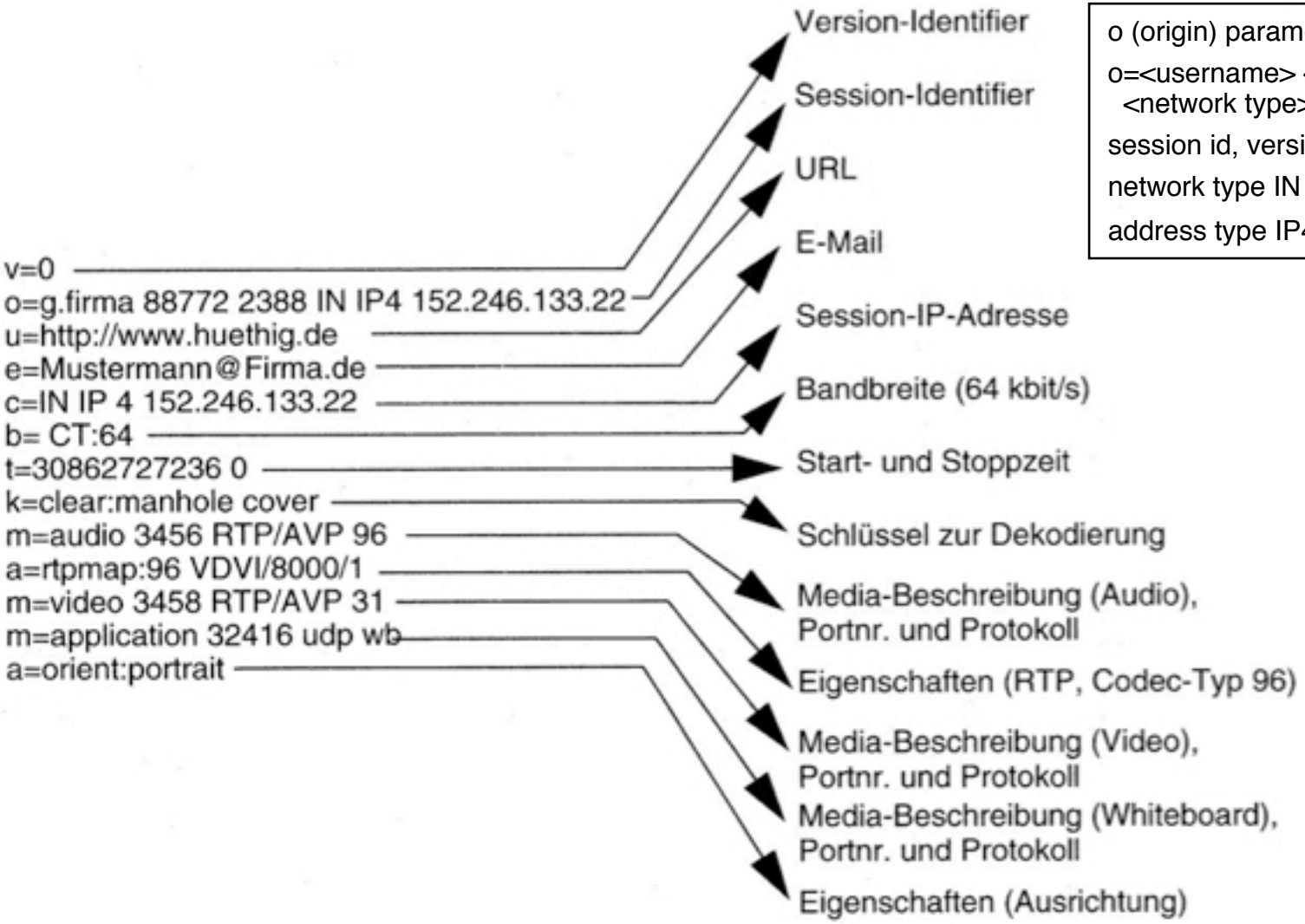
Bild 8.2: SIP Three Way Handshake

Trick/Weber

Example: SIP Message

```
INVITE sip:john@domain.com SIP/2.0                          Start Line

VIA:SIP/2.0/UDP 169.130.12.5                                General Header
Call-ID:187602141351@worchester.bell-telephone.com
From:<sip:a.g.bell@bell-telephone.com>
To:T.A.Watson<sip:watson@bell-telephone.com>
CSeq:1 INVITE                                               Sequence Number

Subject:Mr. Watson, come here                               Request Header

Content-Type:application/sdp                                Entity Header
Content-Length:885

v=0                                                         Body: SDP Data
o=bell 53655765235368763 7 IN IP4 128.3.4.5
c=IN IP4 135.180.144.94
m=audio 3456 RTP/AVP 0 3 4 5
```

SDP Information



o (origin) parameter:

o=<username> <session id> <version> <network type> <address type> <address>

session id, version: NTP timestamp

network type IN = Internet

address type IP4 or IP6

SDP Media Description and Attributes

- Media description (*m*)
  - Media type (e.g. *audio*)
  - Used port number
  - User data transport protocol
    - » e.g. RTP/AVP = Real-Time Transport Protocol, Audio/Video Profile
  - List of available formats/codecs
    - » "96" in previous example, may be a list of options
- Attribute description (*a*)
  - Codec details for all mentioned media formats
  - E.g. from "rtpmap" in RTP/AVP standard (IETF RFC 3551)

Example for Multiple Media Formats

```
m=audio 2410 RTP/AVP 0 8 3 4
a=rtpmap:0 PCMU/8000
a=rtpmap:8 PCMA/8000
a=rtpmap:3 GSM/8000
a=rtpmap:4 G723/8000
```

- Communication partner announces the codecs/formats which are locally supported
- Standardized list of RTP-Codecs in RTP/AVP standard, excerpt:

Payload type	Encoding name	Media type	Clock rate	Channels
0	PCMU (μ-law)	A	8000	1
1	reserved	A		
2	reserved	A		
3	GSM	A	8000	1
4	G723	A	8000	1
5	DVI4	A	8000	1
6	DVI4	A	16000	1
7	LPC	A	8000	1
8	PCMA (a-law)	A	8000	1

Codec Negotiation by Offer&Answer

- In connection establishment dialogue (3-way handshake):
  - Partner A sends *offer* (list of supported codecs) as SDP part of *INVITE*
  - Partner B selects appropriate options and specifies them as SDP part of *OK*
- Example:
  - Offer:

    ```
    m=audio 2410 RTP/AVP 0 8 3 4
    ```

  - Answer:

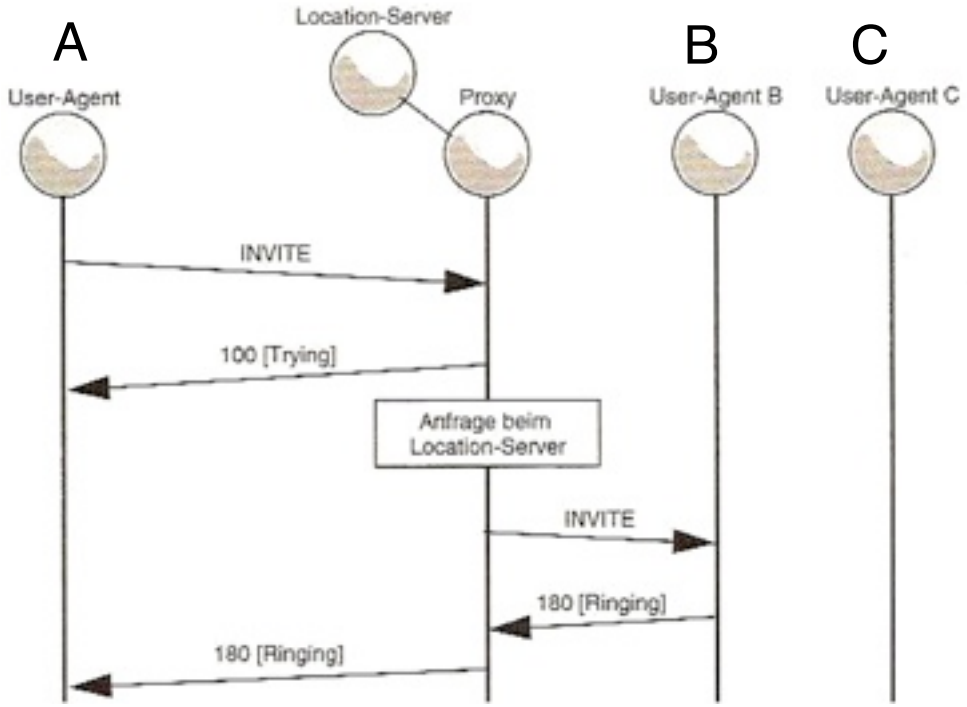
    ```
    m=audio 2468 RTP/AVP 0 3
    ```

- Analogous negotiation for multiple media channels
  - E.g. audio + video
  - E.g. chat, possibly encrypted
  - E.g. file transfer

SIP Proxy Servers

- *Proxy Servers* realize message routing
  - Proxy server forwards SIP messages
  - Takes local decisions on routing
  - In some cases initiates more complex signaling sequences
- Stateless proxy server:
  - Just forwards messages, only routing decisions taken
- Stateful proxy server:
  - Active network element
  - Stores status of incoming requests
  - May create new requests on its own

Example: Parallel Call Forking (e.g. Call Center)



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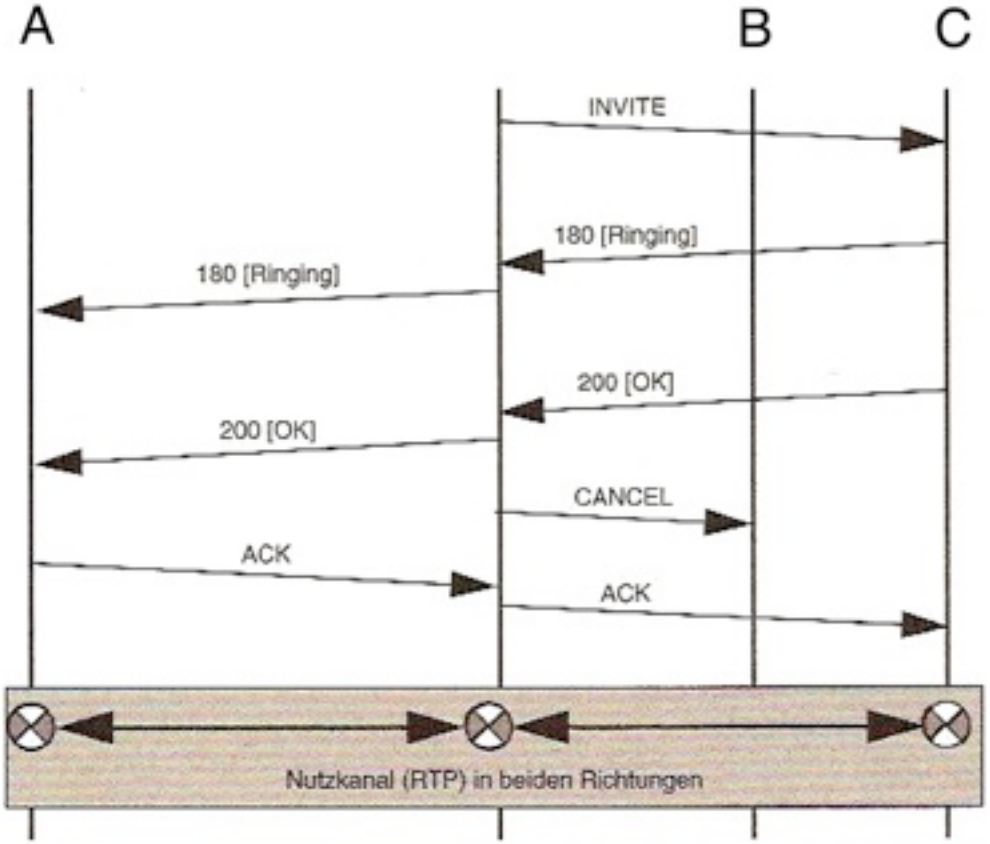
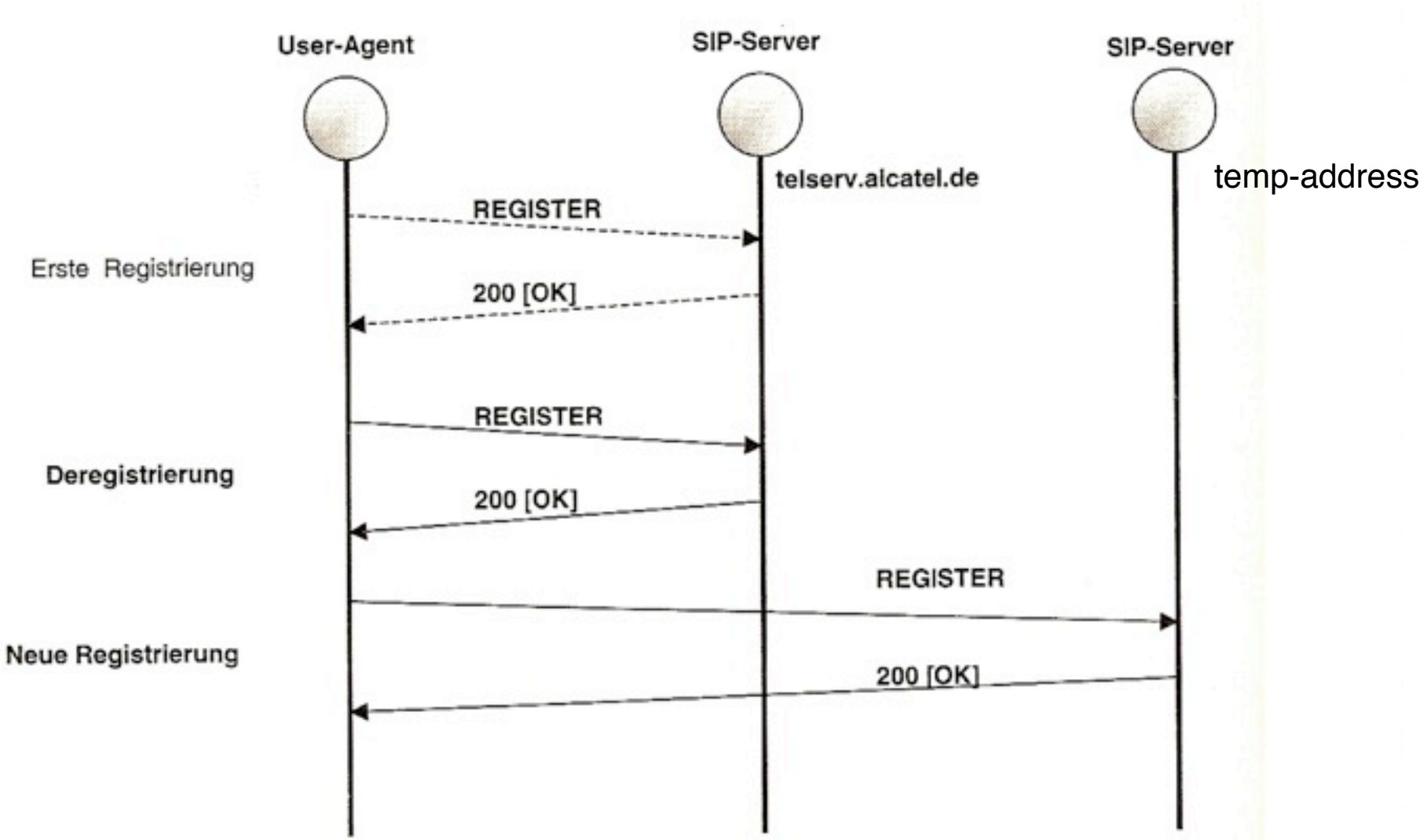


Example: Personal Number

- Incoming call for personal number triggers selection software in proxy server
- Mon–Fri 8–18:
  - Laptop online? If yes: Call there
  - If not: Mobile phone online? If yes: Call there
  - If not: Desktop computer active? If yes: Call there
  - If not: Call office phone with time limit
  - If time limit exceeded: Send email to office email address
- Mon–Fri 18–8 and Sat/Sun:
  - Send email to private email address and send SMS to mobile phone number

- *Service creation:* Developing service logic programs like above
  - In traditional telephone networks: “Intelligent network” (IN)

Example: Mobile User Registration



SIP and UMTS

- UMTS = Third generation of cellular mobile network (IMT-2000)
  - (1st: Analog, 2nd: GSM)
  - UMTS provides unique standard for Europe, USA and Japan
  - Continued extension of standard by "3rd Generation Partnership Project" (3GPP)
- UMTS covers pico cells, urban cells, suburban cells, global cells
- UMTS Specification Releases
  - Since release 4 and 5: Mobile multimedia system with new core network
    - » IP based core network
  - Separation between call control and bearer control in Release 4
  - "Internet Multimedia Subsystem" (IMS) in Release 5: Call control over SIP only

13 Signaling Protocols for Multimedia Communication

13.1 Signaling and Sessions

13.2 SIP Basics

13.3 Signaling for Instant Messaging

Literature:

www.ietf.org/impp
www.xmpp.org

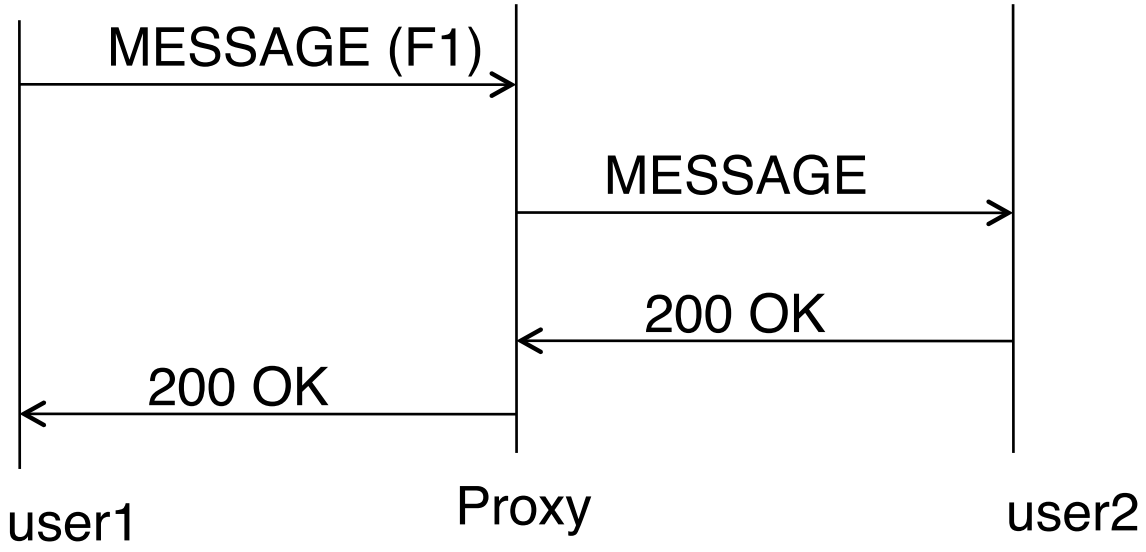
Instant Messaging (IM)

- Exchange of text information between clients in real-time
- Usually combined with *presence information*
- Traditionally computer-based, but may be used on other devices
- Modern clients often integrated with audio/video conferencing
- History:
  - 1970s: Terminal-based messaging (e.g. Unix “talk”)
  - Commercial GUI-based systems: ICQ (1996), AOL Instant Messenger (1997)
  - Many incompatible systems: Yahoo, MSN, Excite, ...
  - 2000: Open-source protocol “Jabber”, developed into XMPP
  - Current: Multi-protocol clients, e.g. Adium, Digsby, Pidgin, Trillian, iChat, ...
- Architecture:
  - Many clients, few servers
  - Device-based or network-based (server-based)
  - Centralized servers (e.g. ICQ) vs. decentralized servers (e.g. Jabber)

Signaling for Instant Messaging

- Proprietary protocols for specific services!
- Several efforts for standardization, two important examples:
- SIMPLE (SIP for Instant Messaging and Presence Leveraging Extensions)
  - RFCs 3428, 3856, 3863, 4479, ... and many drafts
  - Messaging as extensions of the SIP protocol
  - Currently no multimedia support, just text messages
- XMPP (Extensible Messaging and Presence Protocol)
  - Standardized form of XML-based streaming and presence protocols developed by the “Jabber” community (since 1999)
  - IETF standardization 2002–2004: RFCs 3920-23
  - Quite complete, covers e.g. authentication and encryption, multi-user chat, privacy blocking
  - Increasing support from commercial IM applications
    - » e.g. Google Talk, Apple iChat, Facebook Chat XMPP Interface (2010)

SIMPLE Example (1): Message



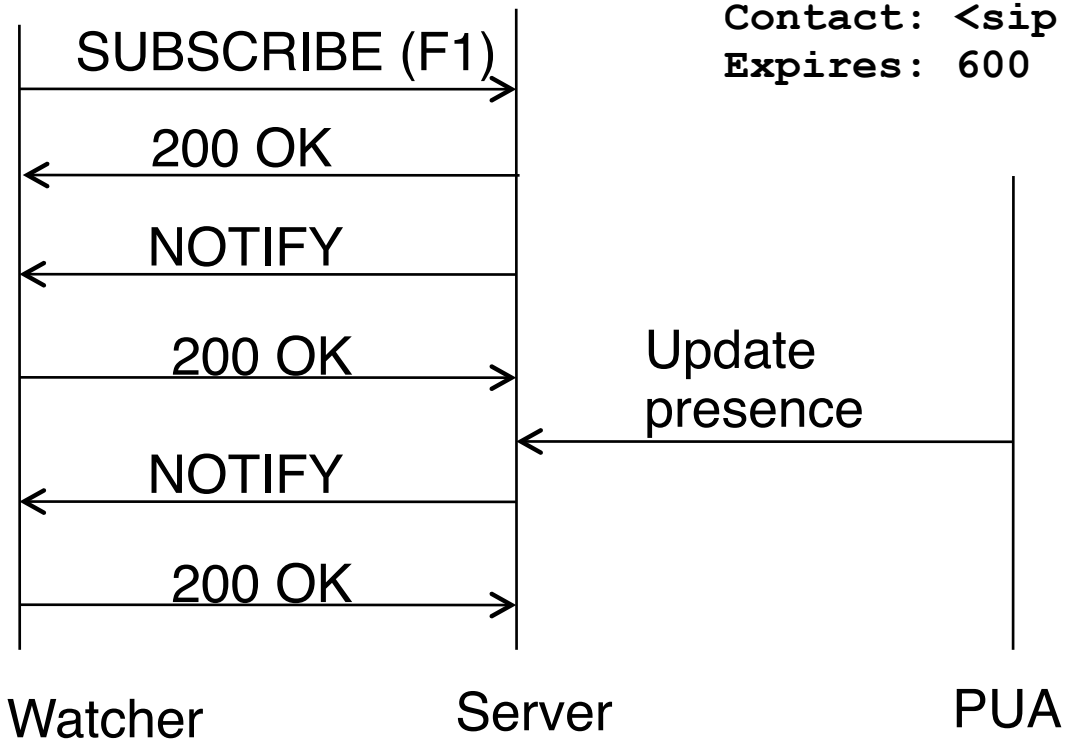
F1:

```
MESSAGE sip:user2@domain.com SIP/2.0
Via: SIP/2.0/TCP user1pc.domain.com;branch=z9hG4bK776sgdkse
Max-Forwards: 70
From: sip:user1@domain.com;tag=49583
To: sip:user2@domain.com
Call-ID: asd88asd77a@1.2.3.4
CSeq: 1 MESSAGE
Content-Type: text/plain
Content-Length: 18
Watson, come here.
```

SIMPLE Example (2): Presence

```
SUBSCRIBE sip:resource@example.com SIP/2.0
Via: SIP/2.0/TCP watcherhost.example.com;...
To: <sip:resource@example.com>
From: <sip:user@example.com>;tag=xfg9
...
Event: presence
Accept: application/pidf+xml
Contact: <sip:user@watcherhost.example.com>
Expires: 600 ...
```

PIDF (RFC 3863):
Presence Indication
Data Format



XMPP

- Based on generic transport protocol for XML streams over the Internet
- Idea:
  - Two-way exchange of XML files of potentially infinite length
  - Transmission of discrete semantic units *(XML stanzas)*

```
<stream>
  <presence>
    <show/>
  </presence>
  <message to='foo'>
    <body/>
  </message>
  <iq to='bar'>
    <query/>
  </iq>
 ...
</stream>
```

iq = info/query

XMPP Example

C ⟷ S

```
C: <?xml version='1.0'?>
   <stream:stream
       to='example.com'
       xmlns='jabber:client'
       xmlns:stream='http://etherx.jabber.org/streams'
       version='1.0'>
S: <?xml version='1.0'?>
   <stream:stream
       from='example.com'
       id='someid'
       xmlns='jabber:client'
       xmlns:stream='http://etherx.jabber.org/streams'
       version='1.0'>
...  encryption, authentication, and resource binding ...
C:   <message from='juliet@example.com'
              to='romeo@example.net'
              xml:lang='en'>
C:     <body>Art thou not Romeo, and a Montague?</body>
C:   </message>
S:   <message from='romeo@example.net'
              to='juliet@example.com'
              xml:lang='en'>
S:     <body>Neither, fair saint, if either thee dislike.</body>
S:   </message>
C: </stream:stream>
S: </stream:stream>
```

Source: RFC 3920

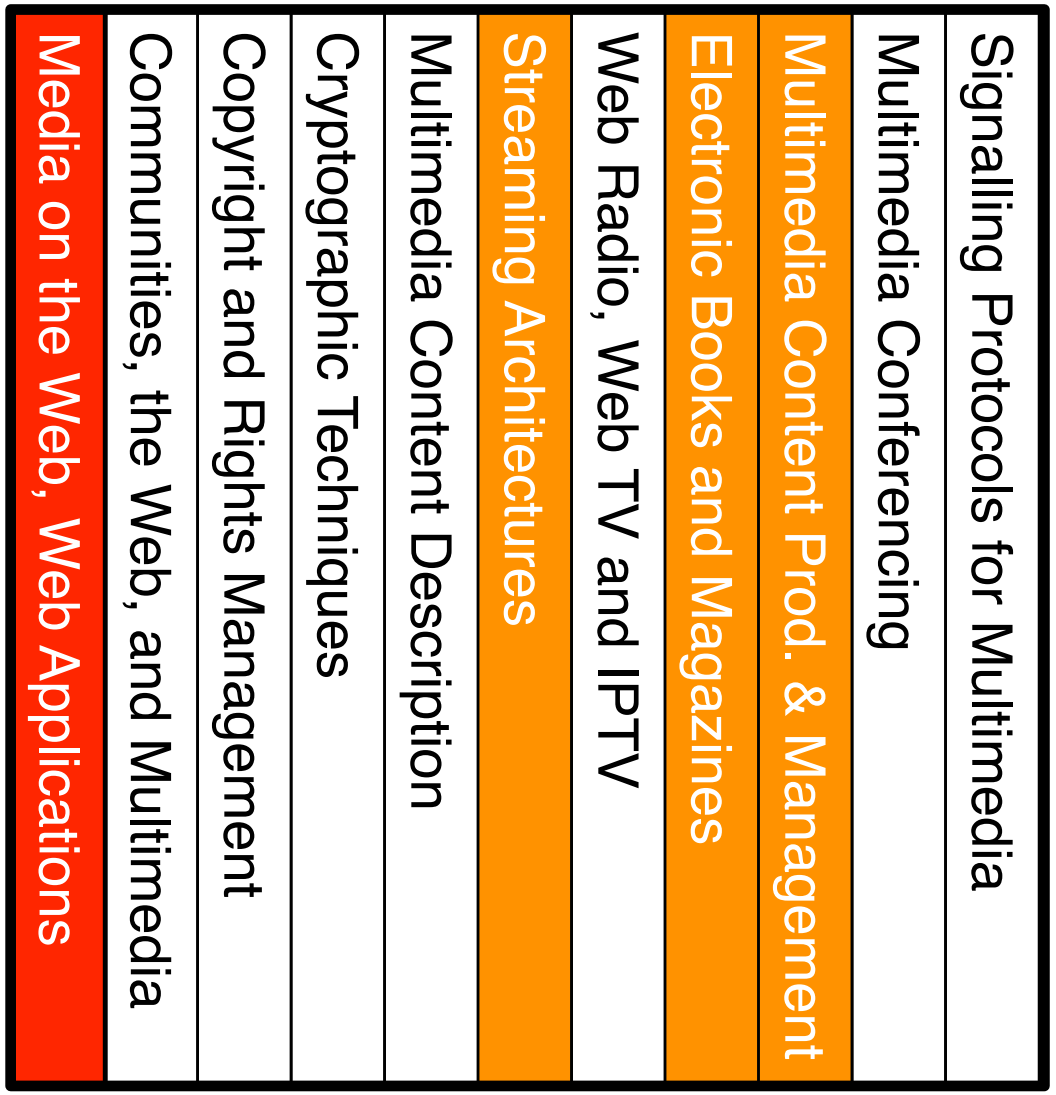
14 Visions and Outlook

Fictitious Example: University Video Platform

- Assume a large university with high international reputation wants to build upon its growing pool of video recordings from lectures and other teaching-related events
  - Large pool of video material of varying length and quality exists
  - Video pool is being expanded on a daily basis
  - Many different authors with different attitudes can potentially contribute
- Goals:
  - Material shall be made available through a common and unique portal
  - Video clips shall be retrievable based on scientifically relevant keywords (e.g. "growth", "awareness", "collaboration", "eigenvalue")
  - Foreign material (from the Web) shall be integrated
  - Composition, structuring, linking shall be created in an online community process

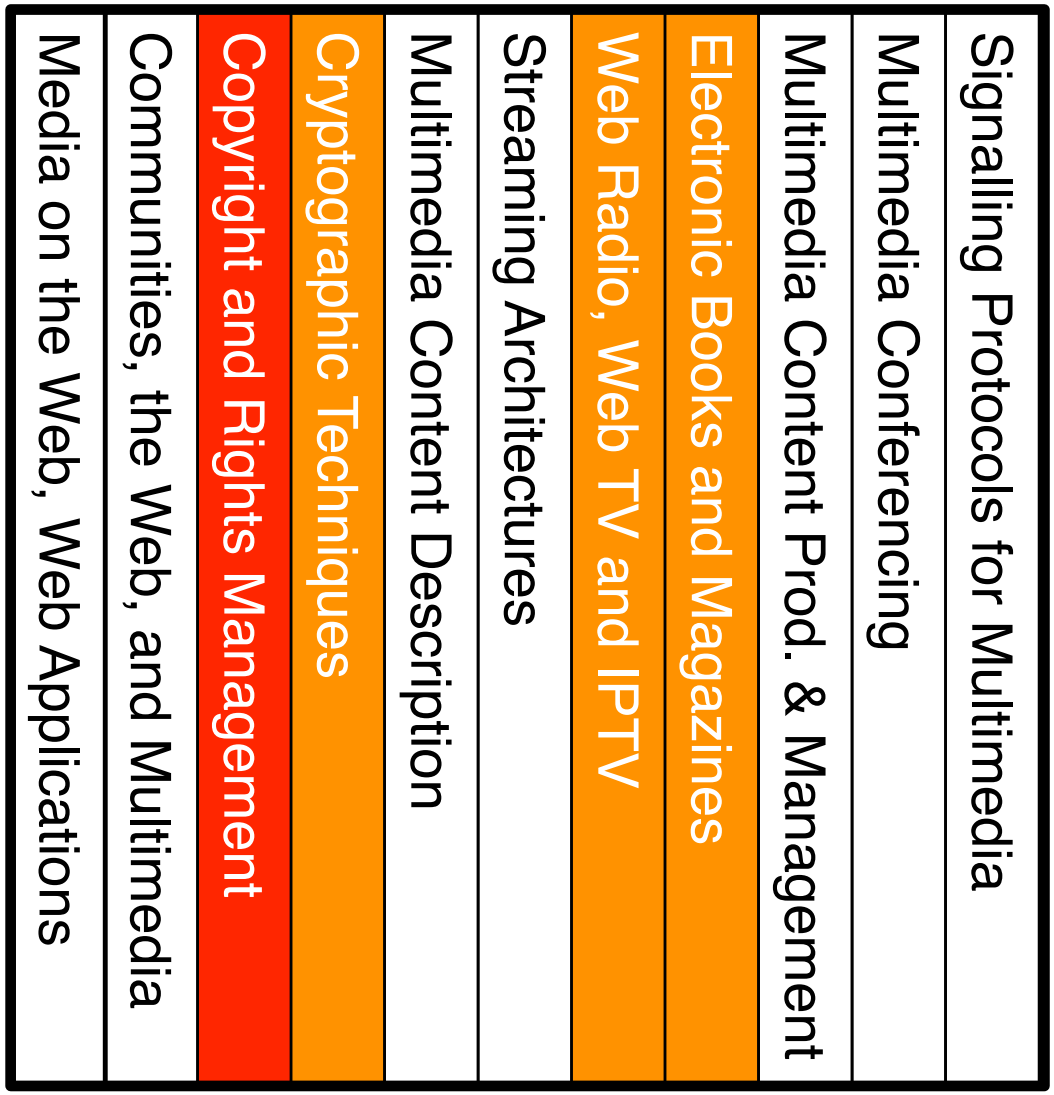
Platform Considerations

- Use commercial platform (e.g. Apple iTunes U)?
  - Extensibility?
  - Control, restrictions?
- Which degree of interactivity?
- What are the target platforms?
  - Operating systems (Windows, MacOS, Linux, Android, iOS, Symbian, ...)
  - Media players (QuickTime, Flash, HTML5 etc.)
- Mobile devices (Mobile phones, tablets)



Content Considerations

- Which rights do we get from the content producers?
- Do we need to protect the content against unallowed use?
- Which security measures are adequate?
  - How big is the overhead for security in terms of performance and usability?
- Do we want to create open channels with high public visibility also?



Metadata Considerations

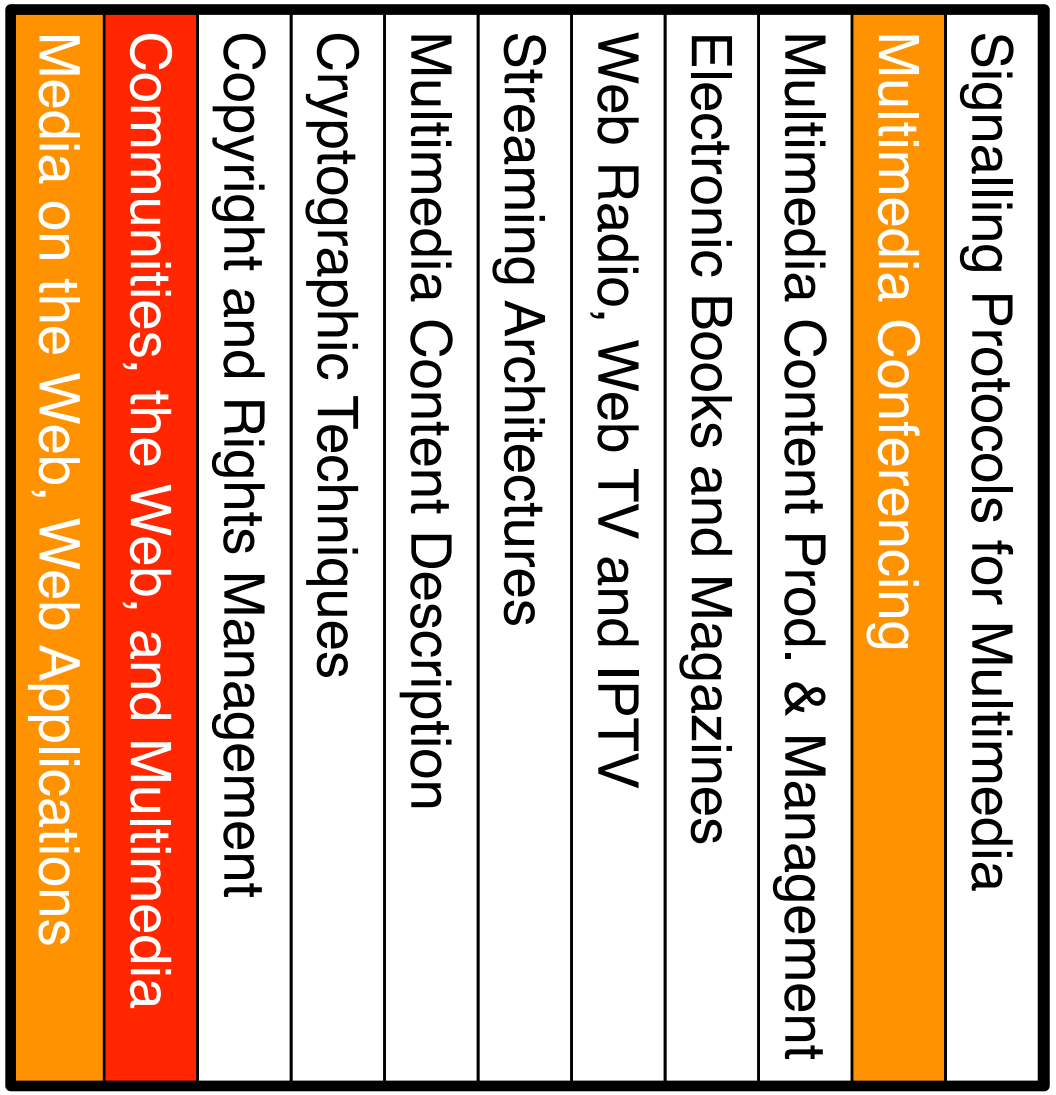
- How can users find the video clip they are interested in?
- How get video clips segmented and annotated with tags/keywords?
- Who produces the standard metadata (author, duration, title, location, date, ...)?

Network Considerations

- Which network capacity is required, which is available?
- How can multi-user request be used to optimize distribution? (multicast etc.)
- Which organizational constraints shall be observed? (centralized / decentralized control)
- How shall reponsibilites be distributed? (master/peer)

Collaboration Considerations

- Which degree of adaptation to users is required?
- To which degrees can users enter information into the system?
  - To which degree can we trust the users?
- Which kind of communication among users shall be integrated into the solution?
- Which kind of community shall be created? (e.g. specialized / integrated into other social networks)

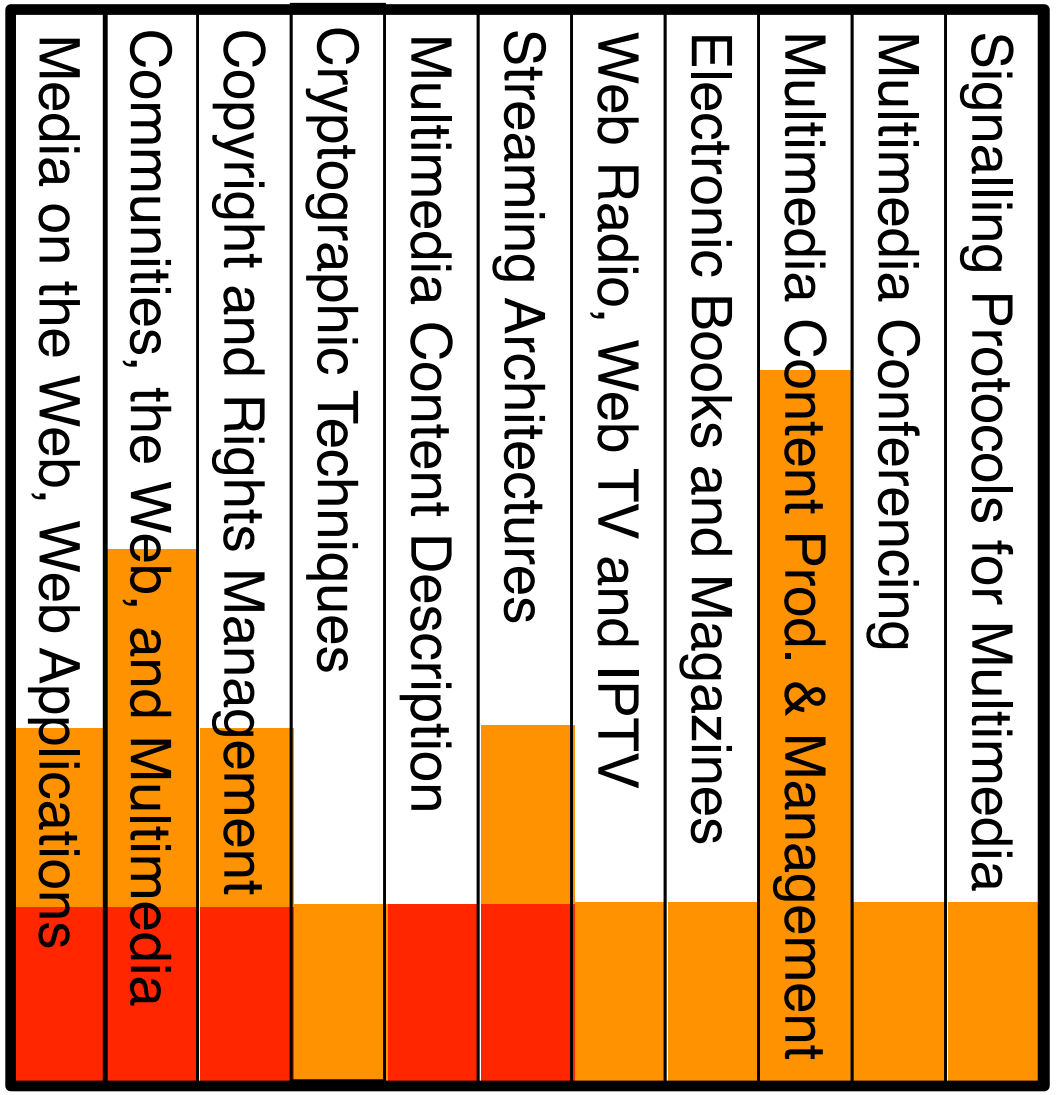


Economic Considerations

- Which is the underlying business model?
- How can revenues be generated?
- What are the involved production chains, and how does the solution fit into them?

Summary: All Aspects

- All aspects are relevant for a practical project
  - Some to a higher, some to a lesser degree
  - Individual profiles of projects (in relevance of aspects) are likely
- A *system engineer* or a *product innovation responsible* needs to be aware of all the technical and non-technical aspects mentioned here ***and their interplay***
  - Technical innovations
  - Social developments



14 Visions and Outlook

Prognosen (1)

"Das Auto ist fertig entwickelt. Was kann noch kommen?"
Karl Benz um 1920
Quelle: Frankfurter Allgemeine Sonntagszeitung, 19.5.2002

"Das Telefon hat zu viele ernsthaft zu bedenkende Mängel für ein Kommunikationsmittel. Das Gerät ist von Natur aus von keinem Wert für uns."
Western Union, Interne Kurzinformation, 1876

"Das Radio hat keine Zukunft"
Lord Kelvin, Mathematiker und Physiker, 1897
Quelle: Newsweek 27.01.1997

"Die drahtlose Musikbox hat keinen denkbaren kommerziellen Wert. Wer würde für eine Nachricht bezahlen, die zu niemanden direkt gesendet wird?"
David Sarnoff in einer Rückmeldung zur Investition in das Radio um 1925

"Das Fernsehen wird nach den ersten sechs Monaten am Markt scheitern. Die Menschen werden es bald satt haben, jeden Abend in eine Sperrholzkiste zu starren."
Darryl F. Zanuck, Chef der 20th Century-Fox, 1946

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Prognosen (2)

"Ich glaube, es gibt einen weltweiten Bedarf an vielleicht fünf Computern."
IBM-Chef Thomas Watson im Zweiten Weltkrieg
Quelle: Ute Dorau und Peter Woeckel, "Jobreport Informationstechnologie", München 2001

"Es gibt keinen Grund, warum irgendjemand einen Computer in seinem Haus wollen würde."
Ken Olson, Präsident, Vorsitzender und Gründer von Digital Equipment Corp., 1977
Quelle: NZ-Herald, 15.12.2008

"Also gingen wir zu Atari. Und sie sagten, ‚Nein'. Dann gingen wir zu Hewlett-Packard, und sie sagten, ‚Hey, wir brauchen Sie nicht, Sie haben das College noch nicht abgeschlossen'."
Apple Computer Inc. Gründer Steve Jobs über seine Versuche, Atari und H-P an seinem Personal Computer zu interessieren

"In zwei Jahren wird das Spam-Problem erledigt sein."
Bill Gates, 2004
Quelle: NZ-Herald, 15.12.2008

"Das Internet wird kein Massenmedium, weil es in seiner Seele keines ist."
DIE WELT, 24.03.2001

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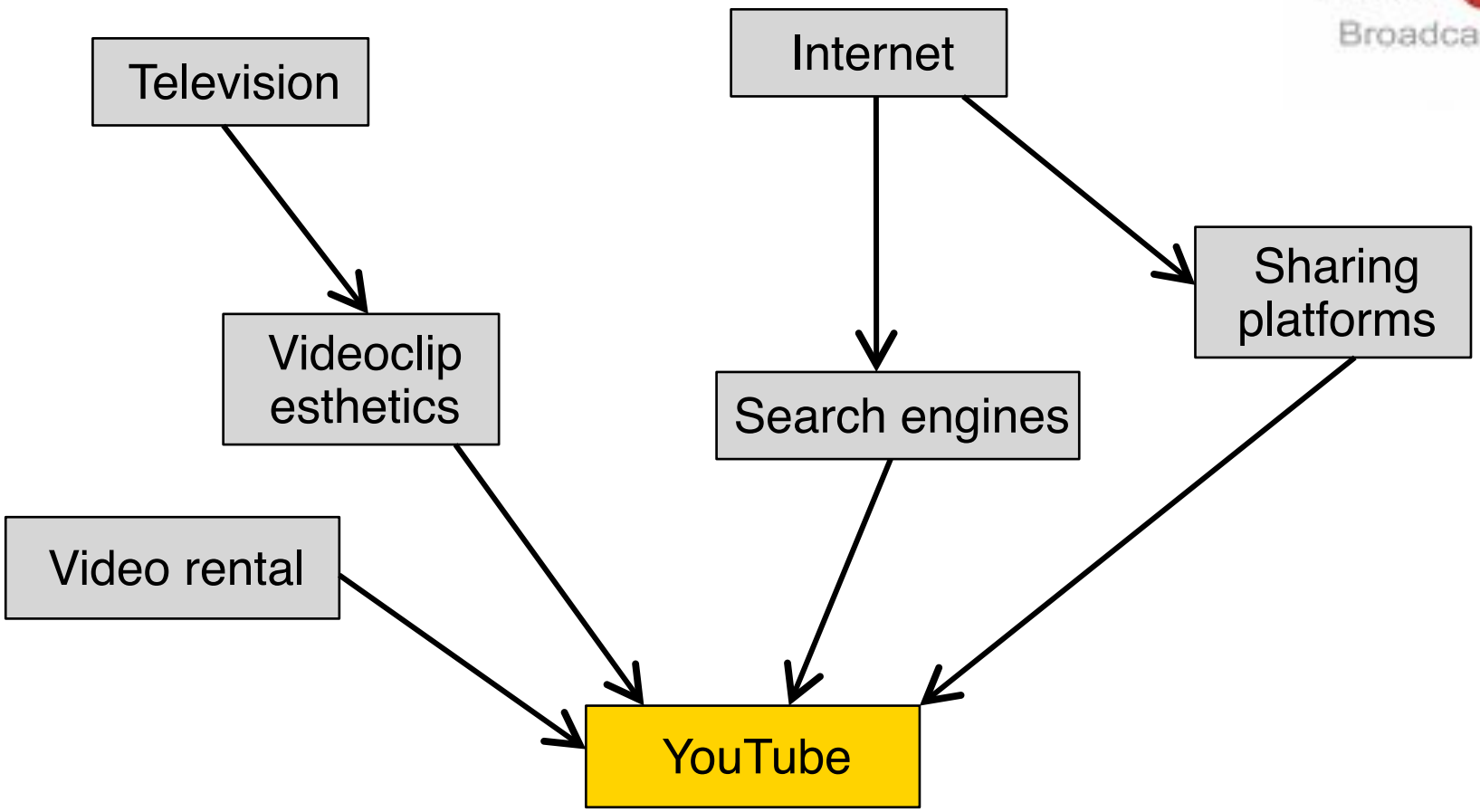
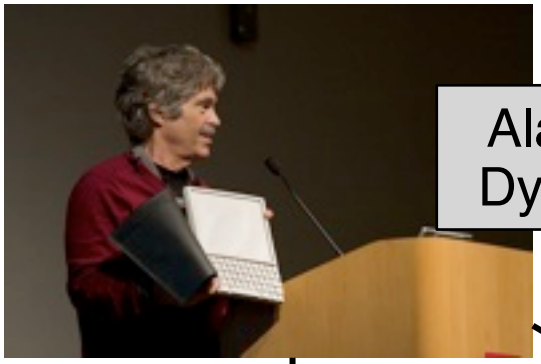
Revolutions and Evolution

- Technological revolutions:
  - Roots in different areas of science (e.g. Laser, Public/Private-Key)
- Transfer revolutions:
  - Known techniques applied in new domain (e.g. Bezier curves)
- Recombination revolutions:
  - New combination of known techniques (e.g. Smartphones)
- *Appropriation* of new technologies does not follow revolutionary scheme but proceeds in evolutionary way:
  - Slow social processes
  - Adaptation of behavioral patterns
  - Learning processes
  - Reputation building

Roots of YouTube



Roots of Apple iPad



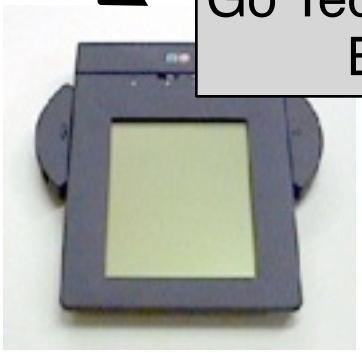
Alan Kay:
DynaBook

1968

Wellner:
Multitouch gestures

1991

Touchpad
gestures



Go Technology
EO

1993

1993

Apple
Newton

2002

Microsoft
Tablet PC

2007

iPhone

iPad 2010

14 Visions and Outlook

Obvious Trends

- Multimedia is not dead at all
  - Modern devices (see iPad) target multimedia mainly
    - » Example multimedia newspaper
  - Multimedia Revolution is still going on
- Networks are being expanded all the time
  - Higher bandwidth
  - Better interoperability
  - Convergence of technologies
- So "Networked Multimedia" is the future, simply?

Speculations (1)

Home environment:

- Assumptions:
  - Network capacity sufficient for mass-delivery of HD video
  - Text input "from the couch" (in a TV setting) is solved satisfactorily
    - » Mobile phones or tablets replacing remote control?
- Consequences:
  - There is no real need for home storage of media data
  - All consumed media can be streamed
  - Terrestric/satellite/cable broadcasting may disappear
  - No CD/Blu-Ray players, video recorders, home media servers anymore
  - Personal Video Recording becomes a "cloud" service
- Forces against this trend:
  - Industry interest in selling diverse specialized devices (home electronics vs. Internet-based service providers)
  - Human interest in physical ownership of property, in haptic experience

Speculations (2)

Mobile environment:

- Assumptions:
  - Mobile network capacity sufficient for mass-delivery of low-resolution video
  - Power consumption / battery capacity problem sufficiently solved (E.g. better batteries, lower energy consumption in screens and networks)
- Consequences:
  - Newspapers and magazines may be replaced by online multimedia
    - » Print media usage goes down, new interactive media evolve
  - Mobile music/video players have unlimited access (at most locations) to owned media content
    - » No synchronization, media "left home"
- Forces against this trend:
  - Technological assumptions may be too optimistic
  - Human interest in independence from electric power, haptic experience of reading a newspaper/magazine

Experience is More Than Trends

- Steve Jobs said several times during the iPad presentation:
  - "You have to feel this experience." (or similar)
  - Better graphics plus good design plus immediate response ***make*** a difference in experience
- New media solutions can be successful only
  - if the experience during usage is at least as fascinating / convenient as with traditional media
  - if they build on existing behavior patterns and product concepts (e.g. book, magazine, TV channel) but go beyond them
- Completely new concepts may appear at any time
  - The term "Internet" exists since less than 30 years! (1974)