SIEMENS

IP Technology in 3rd Generation Mobile Networks

Tutorial, WPMC 01, Aalborg

September 9, 2001

Lara Smith, Joachim Kroß, Hans-Peter Schwefel

{Lara.Smith,Joachim.Kross,Hans.Schwefel}@icn.siemens.de

Siemens AG, Mobile Internet

mobile

© Siemens AG, WPMC01, 9.9.01

Information and Communications

SIEMENS

Trends in Networks:

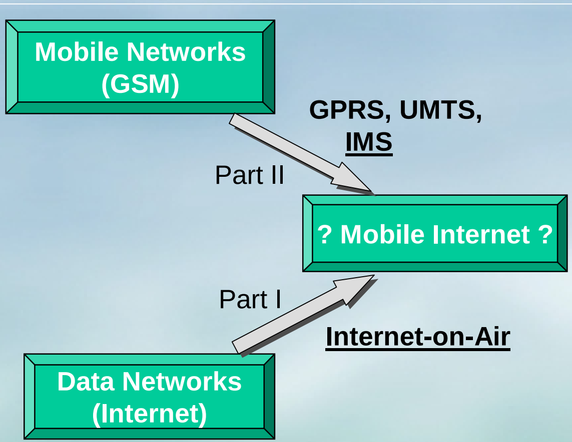
Convergence of Data-Networks and Mobile Networks

Trends in Mobile Networks:

- IP transport in the backbone
- Transport voice & data over IP
- Push IP into the RAN
- Terminate IP in the mobile host
- Separation: Transport ↔ Control

Trends in the Internet:

- Enable wireless access
- Support mobility
- QoS beyond “Best Effort”
- Security and AAA



© Siemens AG, WPMC01, 9.9.01

SIEMENS

Acknowledgements

This slide set is a complilation from various internal presentations. Hence, the following people contributed directly or indirectly to this tutorial:

- Otto Janko
- Peter Kim, Stefan Matt, Erwin Postmann
- Claudia Kämmerer, Stefan Wenk, Paul van Gorb, Christian Bogner
- Markus Placho, Steffen Engmann
- Dirk Kröselberg, Klaus Müller
- Olaf Böhme, Reinhard Frank
- Gernot Reuss, Elmar Haas
- Markus Lautenbacher, Wolfgang Böhm, Antonius Erdmann
- Bernhard Petri, Klaus Hünlich, Wolfgang Hultsch
- ... and many others

SIEMENS

Agenda

- Intro: IP Protocol Family & IETF Standardisation
- Part I: Internet Evolution, Internet-on-Air
  - Principles & Architecture
  - Mobility Support by Mobile IP
  - Quality of Service concepts
- Part II: Mobile Network Evolution, IP Based Multimedia Subsystems (IMS)
  - Evolution/Motivation; Session Initiation Protocol
  - IMS Architecture, Registration, Session Control
  - Interworking, Conferencing, QoS
  - IMS Demonstrator
- Protocol Enhancements: Robust Header Compression, Wireless TCP
- Summary, Questions & Answers

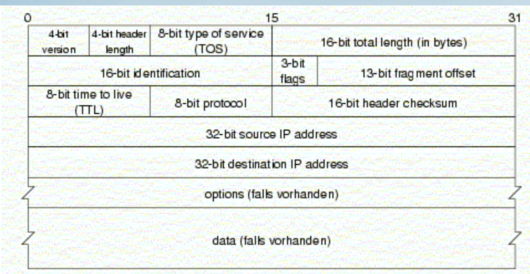
SIEMENS

IP Protocol family & IETF Standardisation

Application	L5-7
TCP/UDP	L4
IP	L3
Link-Layer	L2

Internet Protocol IP:

- **Layer 3 Protocol (Network Layer)**
- **Packet (IP datagram) transmission between hosts (packet size up to 65535 bytes, often restricted by Layer 2 protocols)**
- **Routing using 32 bit adresses (v4)**
- **Most frequent transport protocols**
  Transmission Control Protocol **TCP**
  User Datagram Protocol **UDP**
- **Popular application layer protocols:**
  HyperText Transfer Protocol **HTTP**
  File Transmission Protocol **FTP**
  Simple Mail Transfer Protocol **SMTP**



IP datagram

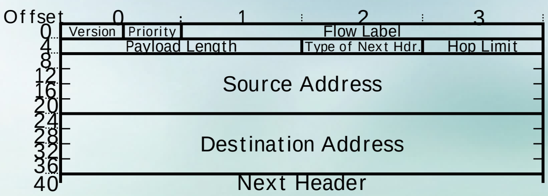
© Siemens AG, WPMC01, 9.9.01

SIEMENS

IP Version 6 (IPv6)

IPv6

- **Basic Header 40 Bytes**
- **128-bit Network Addresses**
- **Flow label (QoS)**
- **No fragmentation in the network**
- **Built-in Security**
- **Neighbor Discovery**
- **Extension Headers:**
  Routing, Fragmentation, Authentication, Encryption



IPv4

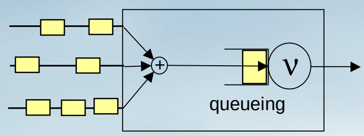
- **Basic Header 20 Bytes**
- **32-bit Network Addresses**
- **Type of Service field**
- **Router may fragment packets**
- **IPsec as an enhancement**
- **ARP (Address Resolution Protocol)**
- **Options**

© Siemens AG, WPMC01, 9.9.01

SIEMENS

IP Protocol: Quality of Service Basics

- Advantages of Packet-Based Transport (as opposed to circuit switched)
  - Flexibility
  - Optimal Use of Link Capacities, Multiplex-Gain for bursty traffic
- Drawbacks
  - Buffering/Queueing at routers can be necessary
  - Delay / Jitter / Packet Loss can occur
  - Overhead from Headers (20 Byte IPv4, 20 Byte TCP)



→ Protocol Improvements for Real-Time Applications necessary
  - Packet Prioritization (DiffServ, TypeOfService field in IPv4)
  - Resource Reservation (IntServ)
  - Connection Admission / Traffic Policing / Shaping
  - Header Compression

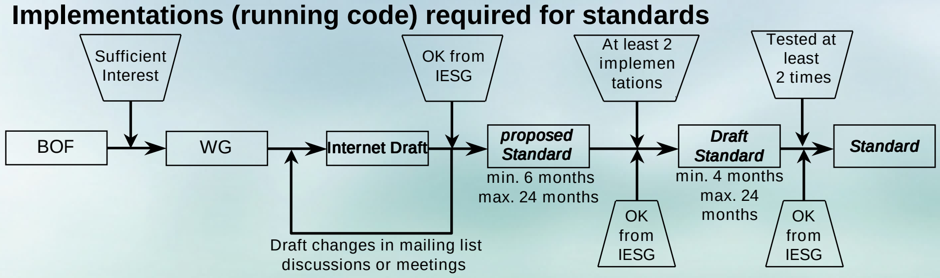
... More about those later

SIEMENS

IETF Standardization Process

Internet Engineering Task Force, IETF (see http://www.ietf.org)

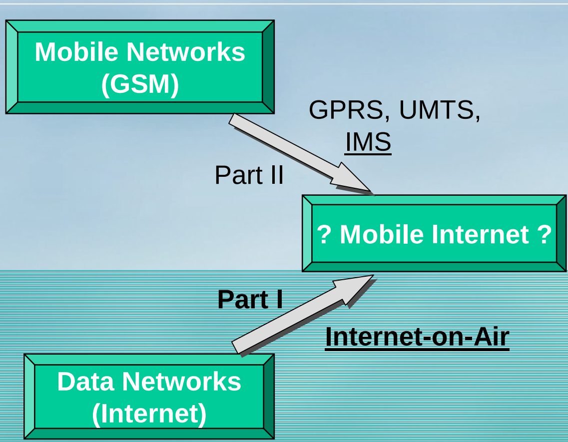
- No formal membership; very informal process
- Protocols are developed in Working Groups (e.g. IPNG, mobileip, mpls, tewg, diffserv, rohc, seamoby, sip)
- Each WG belongs to one of 8 Areas: Applications, General, Internet, Operations and Management, Routing, Security, Sub-IP, Transport, User Services
- Area Directors form Internet Engineering Steering Group IESG
- Implementations (running code) required for standards



SIEMENS

Trends in Networks:
Convergence of Data-Networks and Mobile Networks

Trends in Mobile Networks:
- IP transport in the backbone
- Transport voice & data over IP
- Push IP into the RAN
- Terminate IP in the mobile host
- Separation: Transport ↔ Control



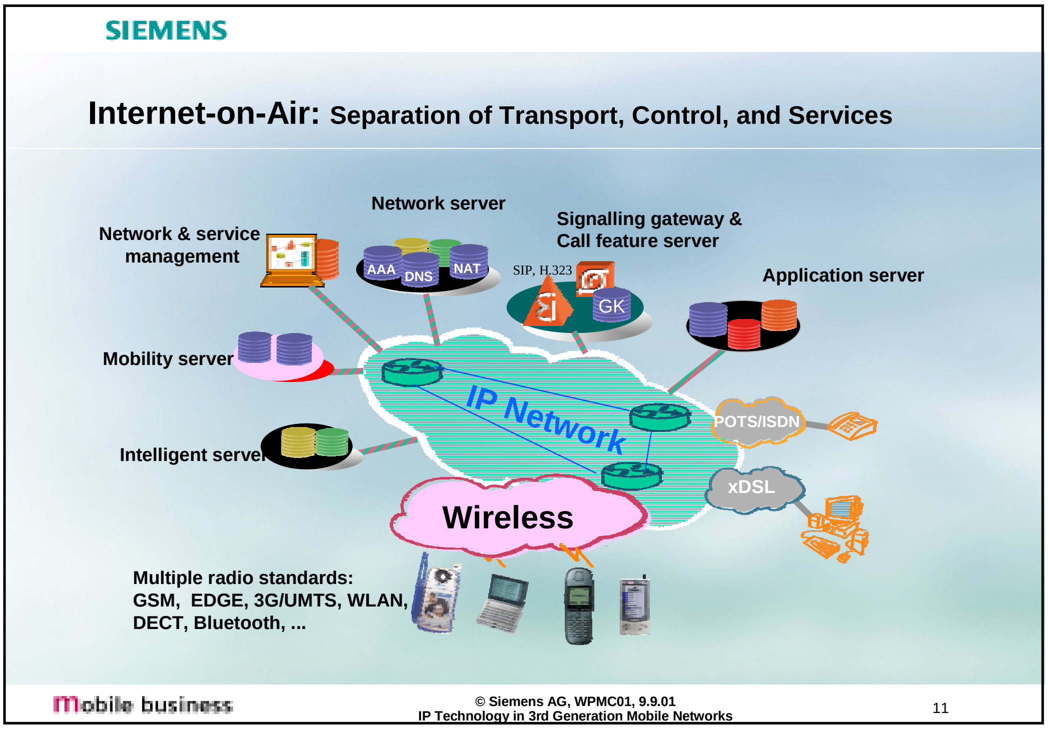
Trends in the Internet:
- **Enable wireless access**
- **Support mobility**
- **QoS beyond "Best Effort"**
- **Security and AAA**

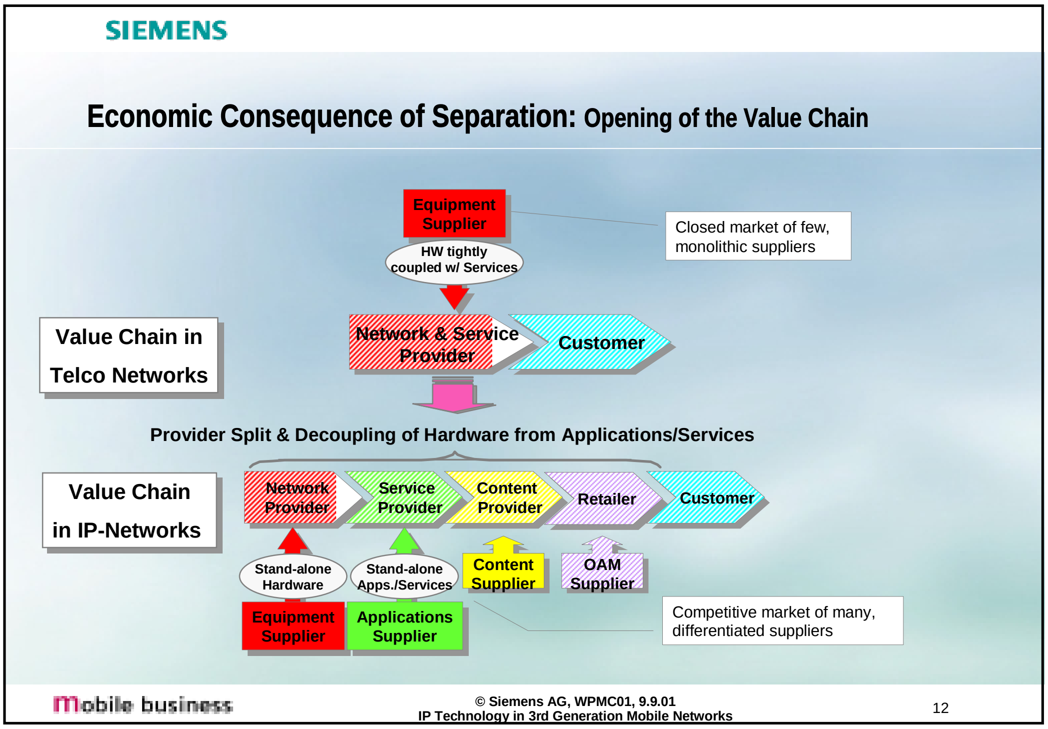
SIEMENS

Evolution of traditional Internet: Internet-on-Air (IoA)

Extension of principles and architecture of traditional Internet to mobile scenarios:

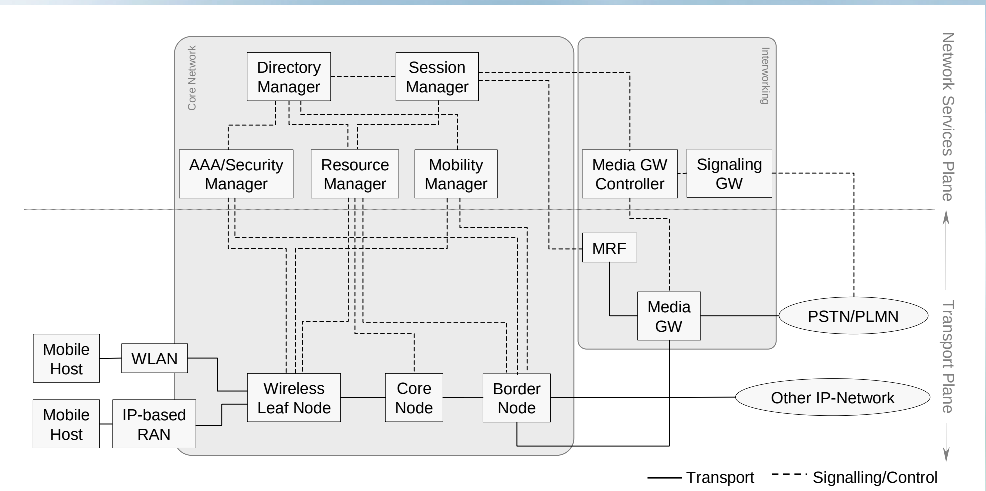
- **Separation of transport, control, and services (transport in core, intelligence at edges)**
- **Flexible 3rd-party applications (Voice over IP is one of them)**
- **End-to-end IP routing**
- **Enhanced network services**
  - Mobility (of terminals and users), Location information
  - Quality of Service (QoS)
  - Authentication, Authorisation, and Accounting (AAA)
    Security
    Charging
- **Independent of wireless access technology (e.g. WLAN, UTRAN,GERAN)**


SIEMENS
Internet-on-Air: Separation of Transport, Control, and Services
Network server
Network & service management
Signalling gateway & Call feature server
AAA
DNS
NAT
SIP, H.323
GK
Application server
Mobility server
IP Network
POTS/ISDN
Intelligent server
xDSL
Wireless
Multiple radio standards: GSM, EDGE, 3G/UMTS, WLAN, DECT, Bluetooth, ...
mobile business
© Siemens AG, WPMC01, 9.9.01
IP Technology in 3rd Generation Mobile Networks
11


SIEMENS
Economic Consequence of Separation: Opening of the Value Chain
Equipment Supplier
HW tightly coupled w/ Services
Closed market of few, monolithic suppliers
Value Chain in Telco Networks
Network & Service Provider
Customer
Provider Split & Decoupling of Hardware from Applications/Services
Value Chain in IP-Networks
Network Provider
Service Provider
Content Provider
Retailer
Customer
Stand-alone Hardware
Stand-alone Apps./Services
Content Supplier
OAM Supplier
Equipment Supplier
Applications Supplier
Competitive market of many, differentiated suppliers
mobile business
© Siemens AG, WPMC01, 9.9.01
IP Technology in 3rd Generation Mobile Networks
12

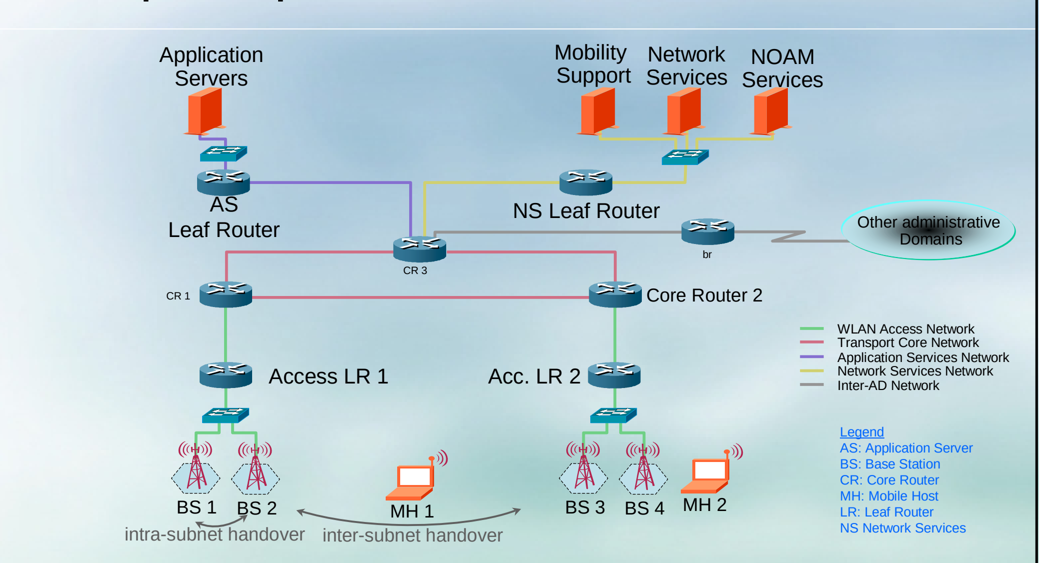
SIEMENS

Simplified IoA Architecture (without application level)



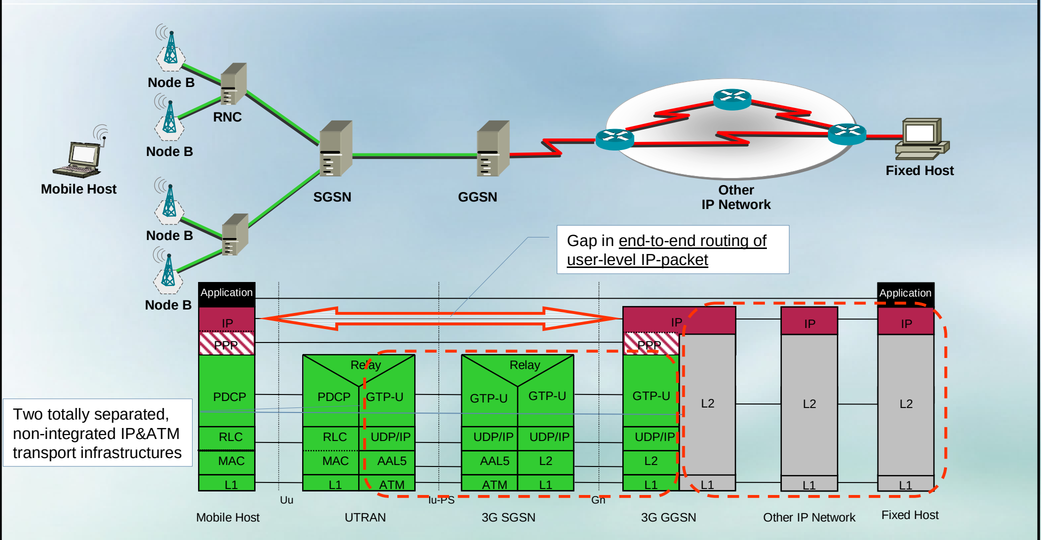
SIEMENS

Simple Example of IoA Network



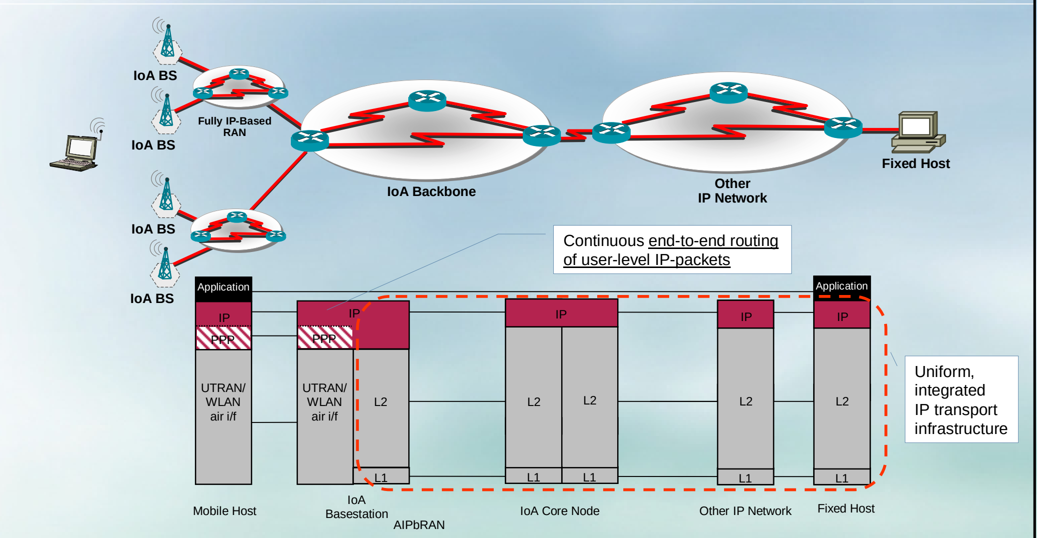
SIEMENS

Transport: no End-to-End IP Routing in UMTS



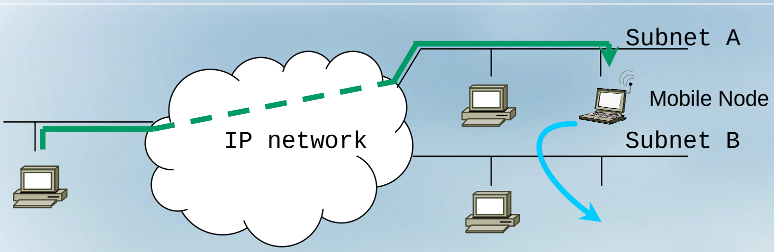
SIEMENS

IoA Transport: IP Routing to the Base Station



SIEMENS

IP Mobility Support: Mobile IP

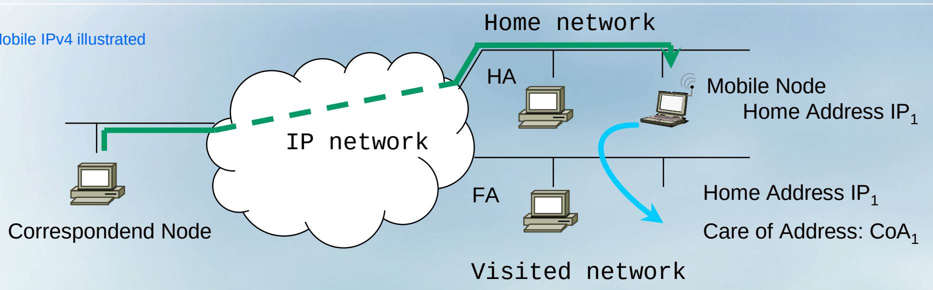


- **Problem: Hierarchical structure of IP addresses (subnetmask)**
  → at transition to other subnet (L3 handover), `normal´ IP routing not sufficient
- **Solution: Extension of IP routing mechanism, `Mobile IP´ (RFC 2002)**

SIEMENS

Mobile IP: Principles & Terminology

Mobile IPv4 illustrated



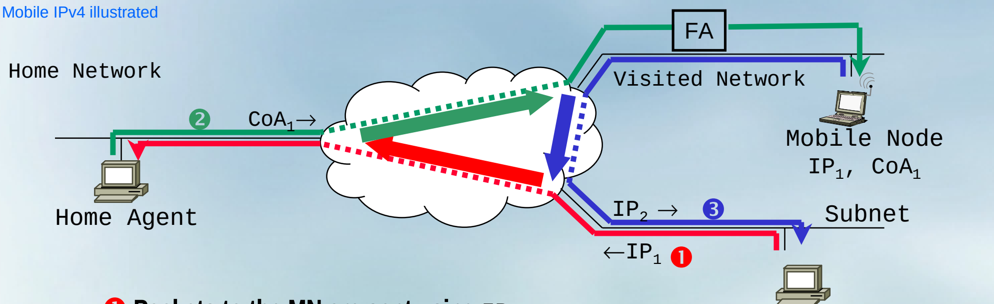
Mobile Node (MN) with fixed IP address IP_1

- **Home Network:** subnet that contains IP_1
- **Home Agent (HA):** node in home network, responsible for packet forwarding to MN
- **Visited Network:** new subnet after roaming / handover
- **Care-of Address (CoA):** temporary IP address within visited network
- **Foreign Agent (FA):** node in visited network, responsible for packet forwarding to CoA

SIEMENS

Mobile IP: Triangle Routing

Mobile IPv4 illustrated



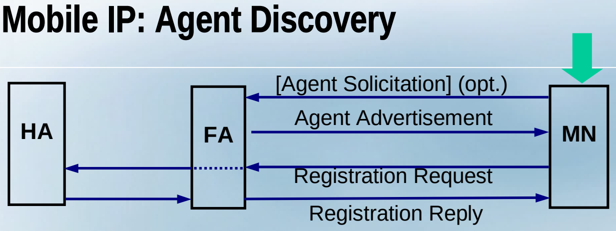
❶ **Packets to the MN are sent using** IP_1

❷ **HA tunnels them to FA, using** CoA_1

❸ **Packets back to the CN are sent using** IP_2 **(without any tunneling)**

SIEMENS

Mobile IP: Agent Discovery



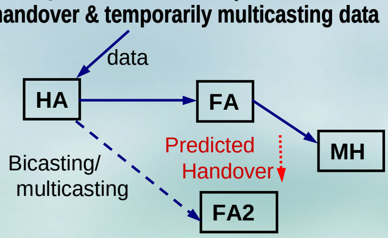
Mobile IPv4 illustrated

- **Mobile Node finds out about FA through Agent Advertisements (can be triggered by an Agent Solicitation from the MN)**
- **Care of Address of the MN is determined, either**
  - **Dynamically, e.g. using Dynamic Host Configuration Protocol (DHCP)**
  - **Or: use IP address of FA as CoA**
- **MN registers at FA and HA**
- **Registration with previous FA simply expires**

SIEMENS

Mobile IP: Additional Issues

- **Authentication,** in particular for registration requests
- **Route Optimization:** avoid triangular routing
- **MIPv6**
  - Large (128 bit) address space → unique c/o addresses
  - Stateless autoconfiguration & neighbor discovery
  - No Foreign Agents
  - Route optimization through IPv6 routing header
- **Handover Optimization** (seamless handover)
  e.g. by predicting handover & temporarily multicasting data



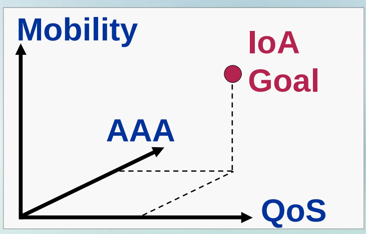
- **Context transfer** (QoS, Header Compression, see later)

SIEMENS

Enhanced Network Services in IoA

- Terminal *mobility* can be supported by Mobile IP
- User *mobility* can be supported, e.g. by Session Initiation Protocol (SIP), see IMS section
- New applications require concepts for
  - *Quality of Service* (real-time applications, e.g. voice, video) [chosen for this tutorial]
  - Security (e.g. Internet banking, electronic cash)
  - Accounting & Charging (content based)

  } Part of AAA
- Combination of concepts & carrier-grade implementation required



SIEMENS

Quality of Service in IoA: Scope

- User Plane QoS
  - End-2-End Packet Delay (in particular interactive applications)
  - Delay Jitter
  - Packet Loss
  - Throughput/Goodput

  [Considered in the following]
- Application Level QoS
  - e.g. Video/Voice Quality (depending on codecs)
- Signalling Plane
  - Call Setup Delays
  - Fraction of blocked Calls
- Behavior at Handover
  - Dropped Calls
  - Delayed / Lost packets
- Reliability Aspects
  - Failure probablities of entities
  - Downtime distribution

SIEMENS

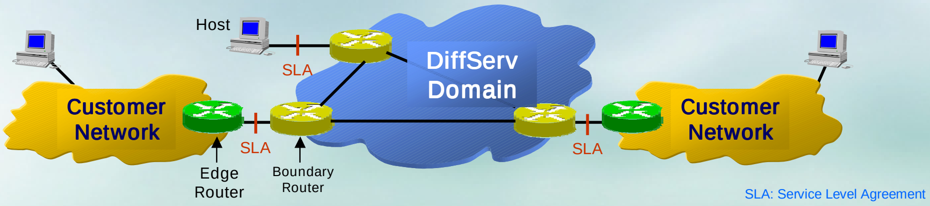
QoS Solution I: Over-Provisioning

- Design network to be able to deal with worst-case traffic scenario
- Advantage:
  - no impact on architecture, protocols and user equipment
  - simplicity
- Problems:
  - Traffic depends on number of active users, user mobility, type of application, daily utilization profile → difficult forecasting
  - Data traffic tends to be very bursty (even `self-similar´)
    → waste of resources if planned for worst-case scenario
    → can be very expensive
  - Unforseeable events can occur (new applications; changes in user behavior, e.g. always-on)

SIEMENS

QoS Solutions II: DiffServ

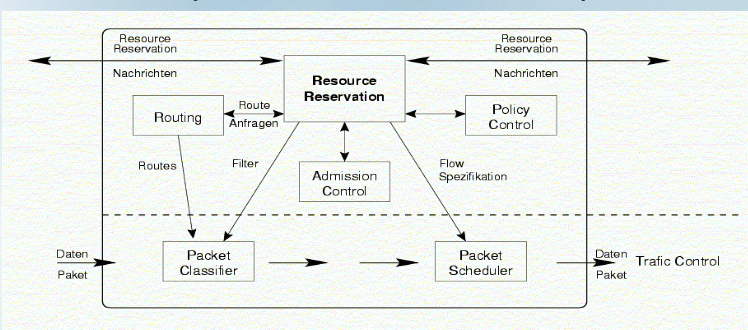
- Basic Idea: reduce queueing delay/loss for critical traffic by preferential treatment at routers
  → improve per-hop transmission behavior
- Packets marked by DiffServ Code Points (DSCPs, 6bit)
- Various scheduling disciplines at routers possible (e.g. static priority, weighted fair queueing)
- Advantage: Simple and scalable
- Problem: No performance guarantees unless used in conjunction with connection admission and traffic shaping/policing at ingress routers



SIEMENS

QoS Solutions III: IntServ/RSVP

- Fundamental Idea: Reserve necessary resources for each traffic flow along its transmission path, which requires:
  - Connection Admission Control (CAC): traffic specification + info about available resources at router → admission decision (if no, then re-routing)
  - Packet Classification: which flow does it belong to?
  - Packet Scheduling: make sure, flow obtains resources as specified



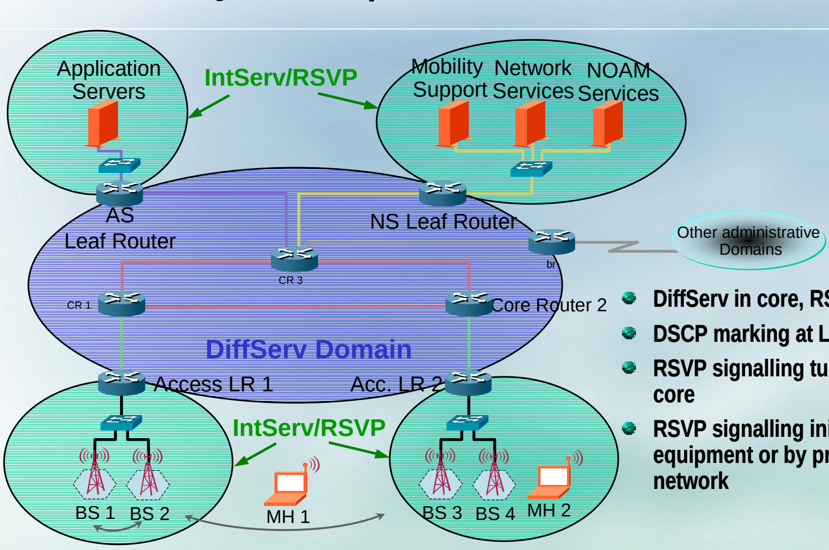
SIEMENS

QoS Solutions III: IntServ/RSVP (cont`d)

- Signalling by Resource Reservation Protocol (RSVP)
  - Path Message: sender initiated, description of traffic parameters and path
  - Resv Message: receiver initiated, causes connection admission/reservation along path; specifies QoS parameters
  - Other messages for reservation teardown and error treatment
  - Soft-State concept: periodic refresh of reservation required
- Advantages:
  - Fine Granularity: per flow treatment, flexible set of QoS parameters
  - Able to provide QoS guarantees (if admission, classification, scheduling is performed correctly)
- Disadvantages
  - Scalability problem: management of state for each single flow
  - Complexity (already connection admission can be complex, e.g. effective bandwidths, etc.)

SIEMENS

Possible QoS Concept for IoA



Legend
AS: Application Server
BS: Base Station
CR: Core Router
MH: Mobile Host
LR: Leaf Router
NS Network Services

- DiffServ in core, RSVP in access
- DSCP marking at Leaf Routers
- RSVP signalling tunnelled through core
- RSVP signalling initiated by User equipment or by proxy in access network

SIEMENS

Integration of QoS & Mobility: Context transfer

- At inter-subnet (L3) handover: necessary to transfer QoS context to new access network
- Possible solutions
  - Perform MIP handover first, transfer QoS context later
    → possibly temporarily reduced QoS
  - Anticipate handover, set up QoS context in advance in new access networks
    → full QoS as soon as Layer 3 connectivity established
    But: simultaneous reservation in several access networks, waste of resources
- Analogous problem for AAA or other context (e.g. for Robust Header Compression)

SIEMENS

IoA QoS: Open Issues [also for IMS QoS]

- Who provides traffic parameters and QoS requirements?
  - User itself?
  - Application layer in mobile station?
  - Automatic mapping of application type and user class?
- QoS Interworking
  - How to map IntServ microflows to DiffServ codepoints?
  - Interworking with QoS mechanisms of external IP networks?
- End-to-end delay
  - What delay budgets assigned to different domains?
- Granularity
  - Complex per-flow signalling and connection admission necessary?
  - Or: Will users accept `soft´ QoS (as provided by simple service classes without connection admission)?
  - Should we concentrate on the bottleneck ´Radio Link´ and use over-provisioning everythere else?
- Relevance/Benefit of Multi Protocol Label Switching (MPLS) and QoS Routing?

SIEMENS

Summary: Internet-on-Air

- Extension of principles and architecture of traditional Internet to mobile scenarios
- Separation of transport, network services, and applications
  → Flexible 3rd-party application provisioning
- Independent of wireless access technology
- Continuous end-to-end IP routing
- Mobility Support using Mobile IP
- Enhanced network services
  - Quality of Service (support of DiffServ, IntServ, MPLS)
  - Security, AAA, and Charging

  and combinations of those concepts

Several aspects still in research
- Seamless handover
- Various QoS questions [also true for IMS QoS]
- Scalability and carrier grade implementation

SIEMENS

mobile

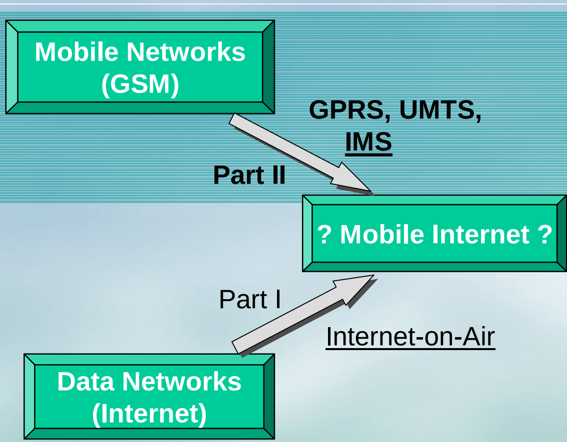
IP multimedia subsystem tutorial

Smith, Product Management Mobile Internet
Siemens, Information and Communication Mobile

SIEMENS

Trends in Networks:
Convergence of Data-Networks and Mobile Networks

Trends in Mobile Networks:
- **IP transport in the backbone**
- **Transport voice & data over IP**
- **Push IP into the RAN**
- **Terminate IP in the mobile host**
- **Separation: Transport ↔ Control**



Trends in the Internet:
- Enable wireless access
- Support mobility
- QoS beyond “Best Effort”
- Security and AAA

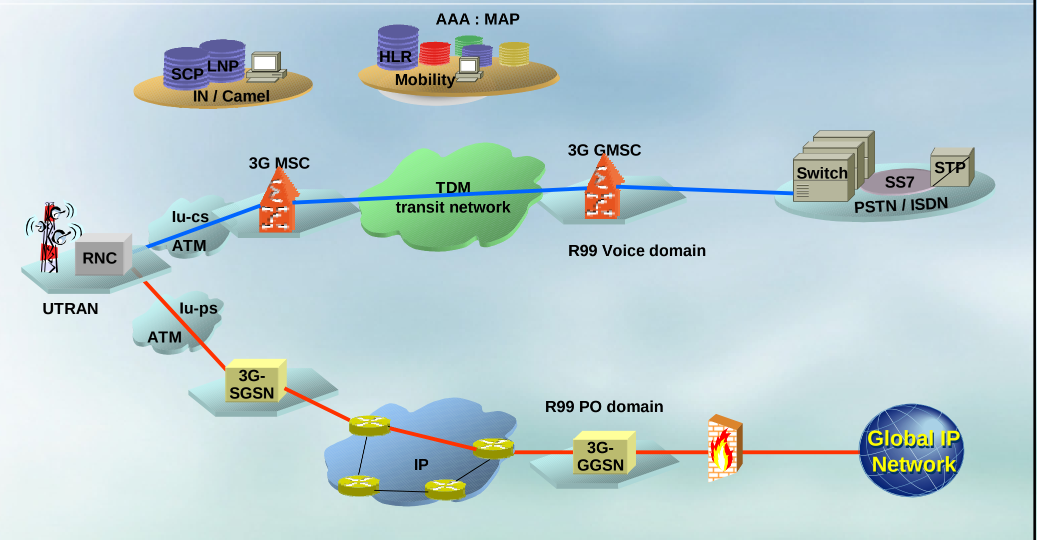
SIEMENS

Agenda (IMS)

- **Introduction to IP Multimedia Subsystem (IMS)**
  - **Evolution of mobile networks**
  - **Motivations for the IMS**
- **Session Initiation Protocol (SIP)**
- **IMS Architecture overview**
  - **Registration**
  - **Session control**
  - **Interworking with PSTN**
  - **Conferencing**
  - **Services**
  - **QoS concept**
- **Summary**

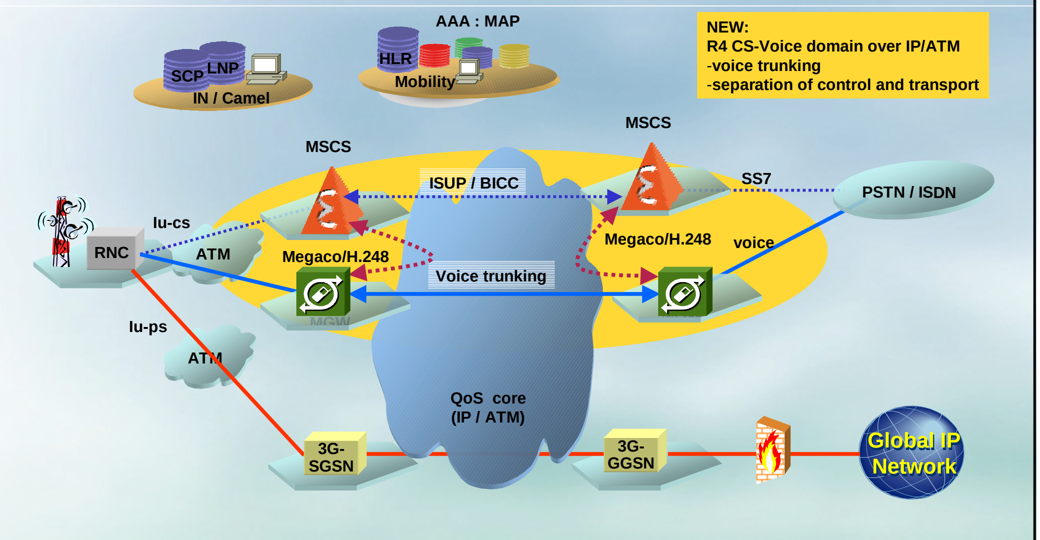
SIEMENS

3GPP R99 architecture



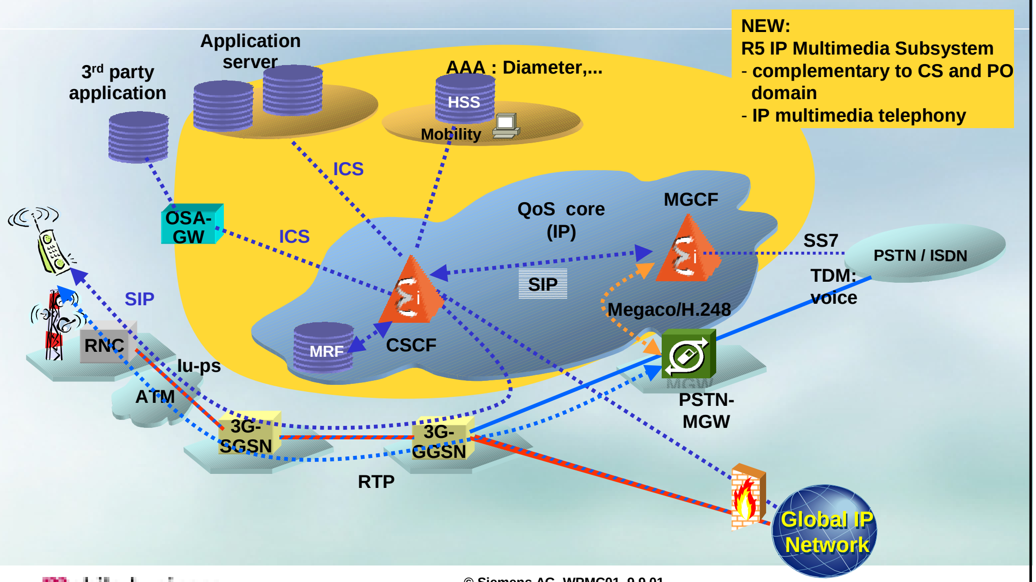
SIEMENS

3GPP R4 architecture



SIEMENS

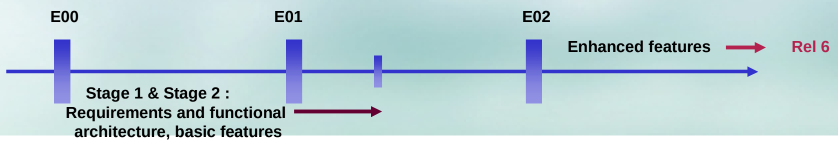
3GPP R5 architecture



SIEMENS

Status of IMS in 3GPP

- Originally: planned to finish IMS specs in 3GPP by end 2001
- Estimation today:
  - 2Q 2002: stage 1 & 2 standards: requirements and functional architecture, basic features
  - Enhanced features - > Rel'6
- Some functional areas stabilize (e.g. basic call flows)
- Several areas rather open (e.g. security, charging)
- Additional functions are identified as necessary over time (e.g. BGCF)



SIEMENS

Motivations for IMS

UMTS IP based Multimedia

- Applications provide new revenue streams for MNOs
- IMS provides infrastructure for integrated real-time/data services.
- IMS benefits:
  - IMS provides standardized infrastructure for integrated applications:
    - Standardized interfaces to applications
    - Standardized and secure authentication, authorization,
    - Standardized charging for services
    - QoS control on the bearer plane for services
    - Global roaming and access to home services
- Without IMS:
  - proprietary application islands
  - often non-compatible protocols used
  - higher OAM
  - difficulties for charging, security, QoS

© Siemens AG, WPMC01, 9.9.01

SIEMENS

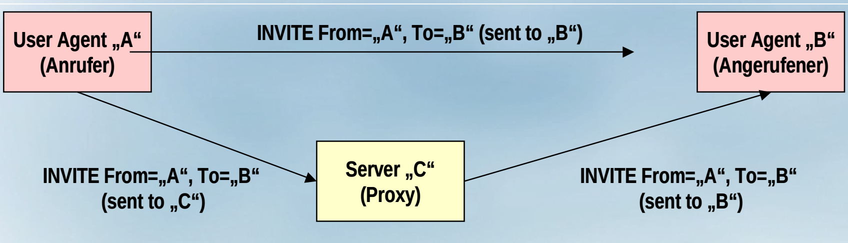
Agenda (IMS)

- Introduction to IP Multimedia Subsystem (IMS)
  - Evolution of mobile networks
  - Motivations for the IMS
- **Session Initiation Protocol (SIP)**
- IMS Architecture overview
  - Registration
  - Session control
  - Interworking with PSTN
  - Conferencing
  - Services
  - QoS concept
- Summary

© Siemens AG, WPMC01, 9.9.01

SIEMENS

SIP: End-To-End and Proxies



- **User agent**: An application program which initiates SIP requests and also acts upon (accepts, rejects or re-directs) incoming SIP requests.
- **Location server:** Location servers provide SIP redirect or proxy servers information about a callee's possible location(s).
- **Proxy server:** A server which takes requests on behalf other user agents or servers and forwards them to the next hop.
- **Redirect server:** A server which accepts a SIP request, maps the address into zero or more new addresses and returns these addresses to the client. Unlike a proxy server, it does not initiate its own SIP request.
- **Registrar**: A registrar is a server that accepts REGISTER requests. A registrar is typically co-located with a proxy or redirect server and may offer location services.

SIEMENS

SIP – Basic messages

- Requests
  - INVITE initiate call
  - ACK confirm final response
  - BYE terminate (and transfer) call
  - CANCEL cancel searches and “ringing”
  - OPTIONS queries features supported by other side
  - REGISTER register with location service
- Responses
  - 1xx Intermediate results (180 Ringing)
  - 2xx Positive confirmations (200 OK)
  - 3xx Redirections (302 Moved Temporarily)
  - 4xx Request-Errors
  - 5xx Server-Errors
  - 6xx Global Errors

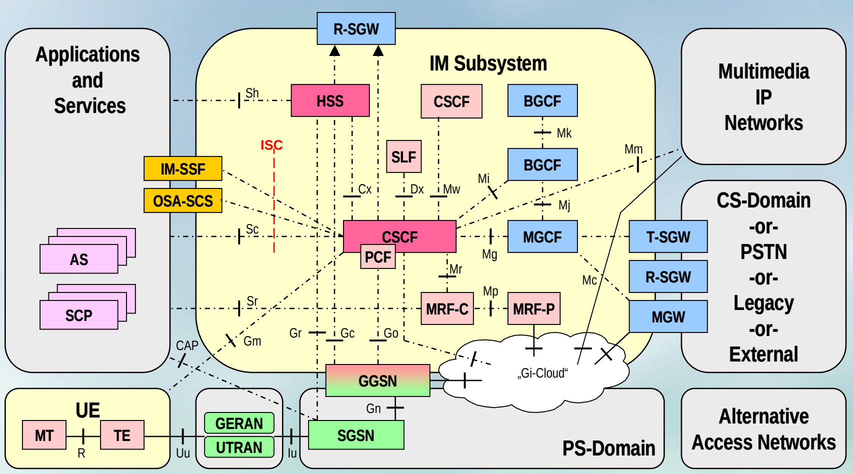
SIEMENS

Agenda (IMS)

- Introduction to IP Multimedia Subsystem (IMS)
  - Evolution of mobile networks
  - Motivations for the IMS
- Session Initiation Protocol (SIP)
- **IMS Architecture overview**
  - Registration
  - Session control
  - Interworking with PSTN
  - Conferencing
  - Services
  - QoS concept
- Summary

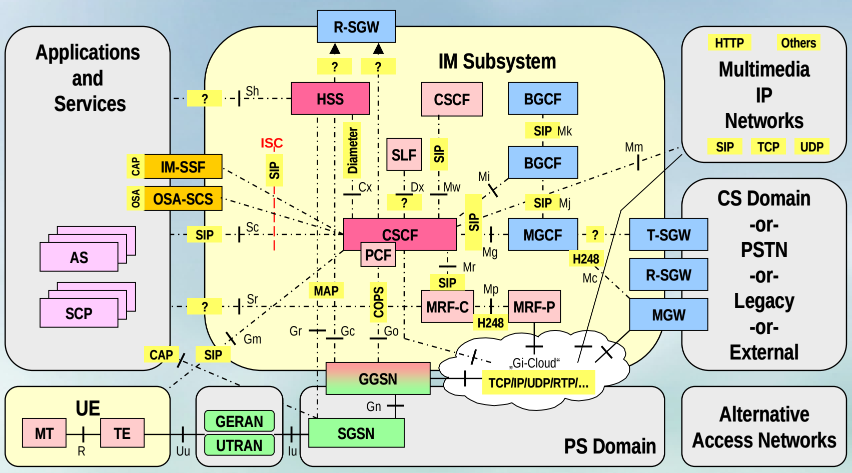
SIEMENS

Network Entities and Reference Points



SIEMENS

Network Entities and Protocols



SIEMENS

Network Entities

- CSCF (Call State/Service Control Function)
- PCF (Policy Control Function)
- HSS (Home Subscriber Service)
- SLF (Subscription Locator Function)
- MRF (Multimedia Resource Function)
- BGCF (Breakout Gateway Control Function)
- MGCF (Median Gateway Control Function)
- MGW (Media Gateway)
- T-SGW (Transport Signaling Gateway)
- R-SGW (Roaming Signaling Gateway)
- AS (Application Server)
- SCP (Service Content Provider)
- IM-SSF (Service Switching Function)
- OSA-SCS (Service Capability Server)

Additionally:
- Charging Entities
- Security Entities
- Lawful Interception
- Firewalls
- DNS, DHCP, TRIP, …
- QoS Entities
- OAM and NM
- …

SIEMENS

HSS

Database for subscriber related information

- Identification (SIP, Mail, E.164, Label, IMSI, ...)
- Location management (P-CSCF, S-CSCF, IP address)
- List of authorized services
- List of subscribed services
- Quintuplets for Security

SIEMENS

P-CSCF (Proxy CSCF)

First contact point of an operator‘s network (for the mobile terminal)

- Forwarding of SIP messages between terminal and core network
- Generation of charging records
- Translation of IDs other than SIP URIs into SIP URIs (e.g. E.164 numbers)
- Termination of confidentiality and integrity
- Authorisation of bearer resources and QoS management
- Detection of emergency calls and selection of a emergency S-CSCF
- Translation of SIP URIs for local services
- Lawful interception
- SIP header compression

I-CSCF (Interrogating CSCF)

First contact point of an operator's network (for other operators)

- Forwarding of SIP messages (proxy functionality)
- Assignment of a S-CSCF
  - during registration
  - during invite (for services for not registered subscribers)
- Generation of charging records
- Hiding of internal network configuration/capacity/topology

S-CSCF (Serving CSCF)

Performs session control and service triggering

- Acts as a registrar according to RFC2543
- May behave as a Proxy Server as defined in RFC2543, i.e. it accepts requests and services them internally or forwards them on, possibly after translation.
  - May behave as a User Agent as defined in RFC2543, i.e. it may terminate and independently generate SIP transactions.
- Interaction with service platform(s)
- Provides endpoints with service event related information
- Generation of charging records
- Authentication (based on quintuplets from HSS)

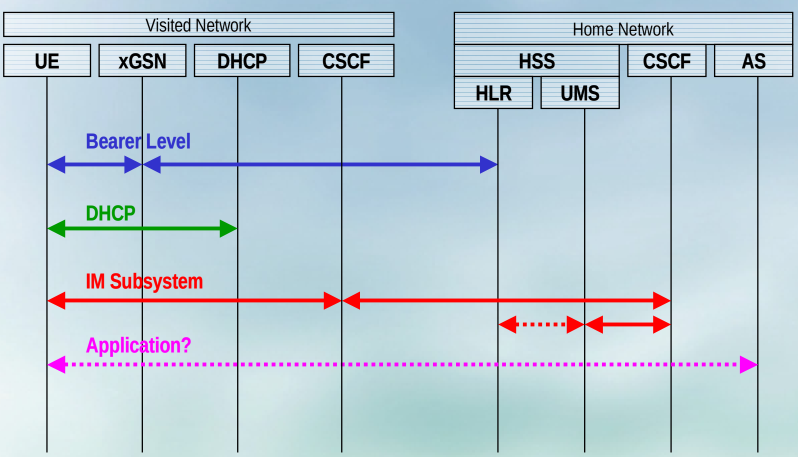
SIEMENS

Agenda (IMS)

- Introduction to IP Multimedia Subsystem (IMS)
  - Evolution of mobile networks
  - Motivations for the IMS
- Session Initiation Protocol (SIP)
- IMS Architecture overview
  - **Registration**
  - Session control
  - Interworking with PSTN
  - Conferencing
  - Services
  - QoS concept
- Summary

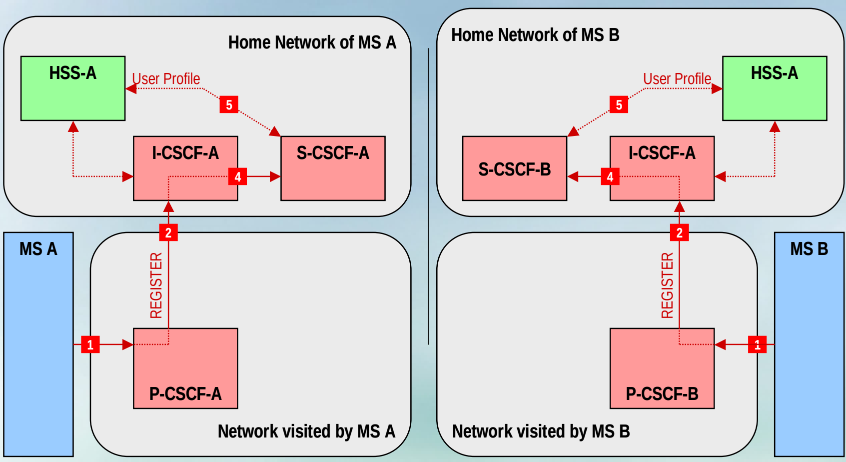
SIEMENS

Levels of Registration



SIEMENS

Registration in a Roaming Scenario



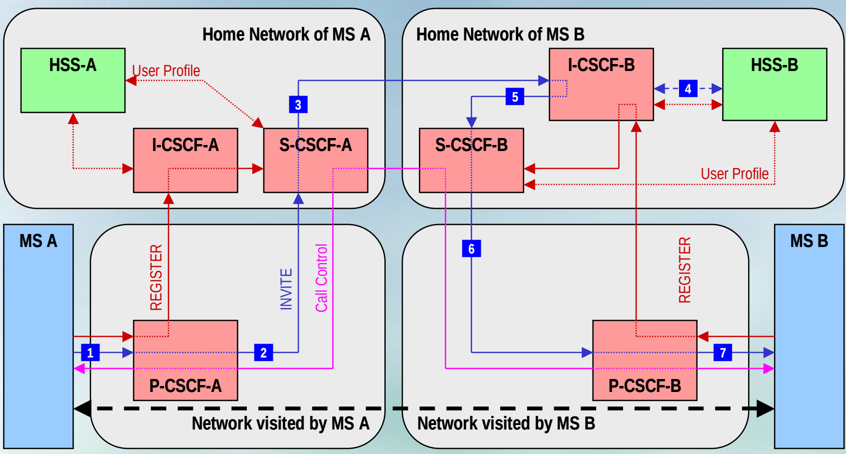
SIEMENS

Agenda (IMS)

- Introduction to IP Multimedia Subsystem (IMS)
  - Evolution of mobile networks
  - Motivations for the IMS
- Session Initiation Protocol (SIP)
- IMS Architecture overview
  - Registration
  - Session control
  - Interworking with PSTN
  - Conferencing
  - Services
  - QoS concept
- Summary

SIEMENS

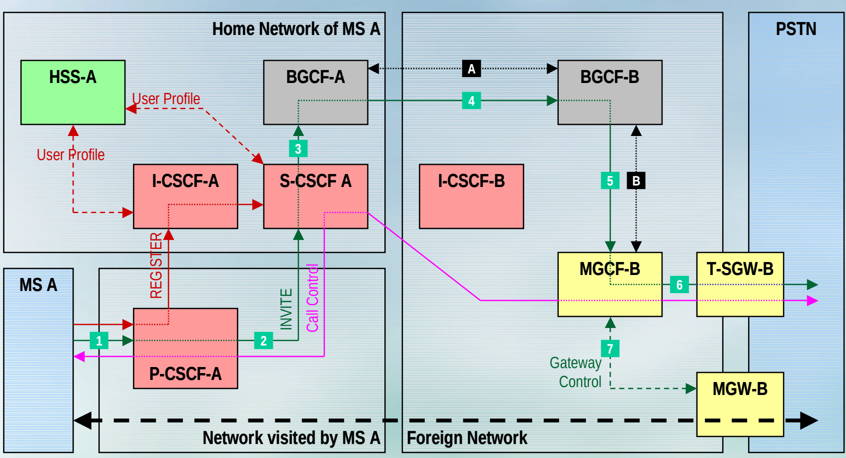
Routing of Mobile-To-Mobile Calls



© Siemens AG, WPMC01, 9.9.01

SIEMENS

Routing of Mobile Calls to CS or PSTN (3GPP)



© Siemens AG, WPMC01, 9.9.01

SIEMENS

Agenda (IMS)

SIEMENS

MRF Functions

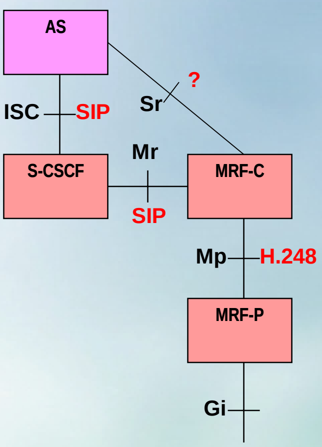
The MRF is responsible for all functions of the core network which interact with the user plane

Agreed
- Conferencing
- Announcements
- Transcoding

Additional
- Interactive voice recognition
- Text to speech processing
- Generations of Tones
- DTMF

SIEMENS

MRF Architecture



MRF-C (Controller)

- Controls the media stream resources in the MRFP.
- Interprets information coming from an AS and S-CSCF (e.g session identifier) and control MRFP accordingly.
- Generates Call Detail Records (CDRs)

MRF-P (Processor)

- Controls bearers on the Gi interface.
- Provides resources to be controlled by the MRFC.
- Mixes incoming media streams (e.g. for multiple parties).
- Sources media streams (for multimedia announcements).
- Processes media streams (e.g. audio transcoding, media analysis).

Application Server

- Conference booking
- Floor control mechanism
- Session Control. Conference IDs

SIEMENS

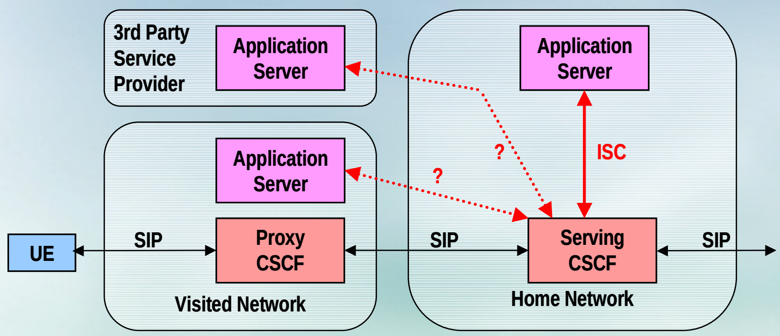
Agenda (IMS)

- Introduction to IP Multimedia Subsystem (IMS)
  - Evolution of mobile networks
  - Motivations for the IMS
- Session Initiation Protocol (SIP)
- IMS Architecture overview
  - Registration
  - Session control
  - Interworking with PSTN
  - Conferencing
  - Services
  - QoS concept
- Summary

SIEMENS

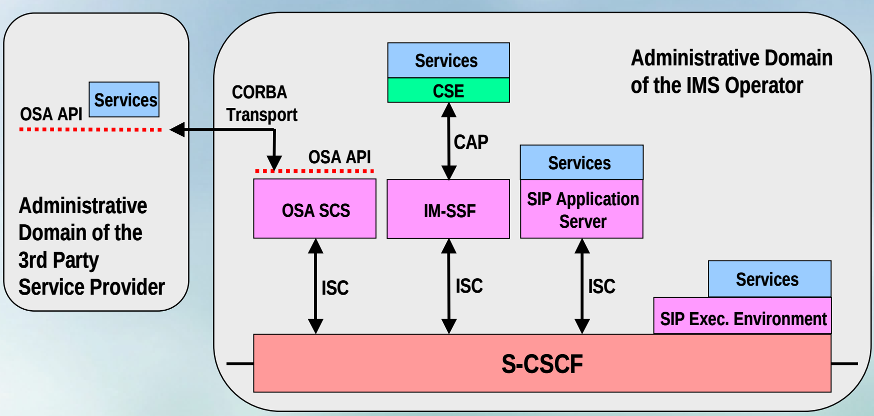
Services are Home Controlled

- The Serving CSCF (S-CSCF) is located in the Home Network
- The Visited Network only provides a proxy (P-CSCF): all calls are always first routed to the Home Network.



SIEMENS

Alternatives to Deploy Services in IMS



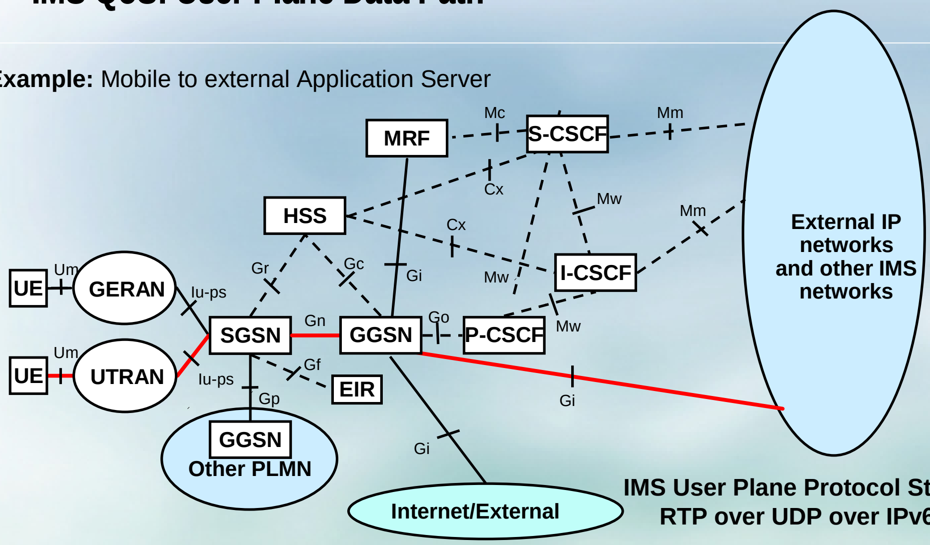
SIEMENS

Agenda (IMS)

SIEMENS

IMS QoS: User Plane Data Path

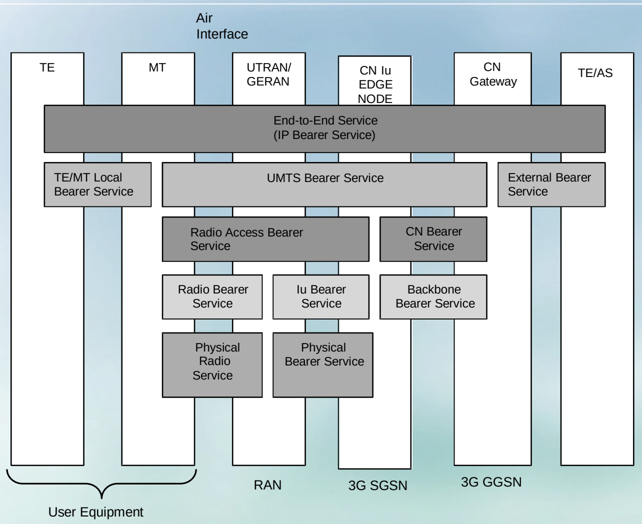
Example: Mobile to external Application Server



IMS User Plane Protocol Stack:
RTP over UDP over IPv6

SIEMENS

IMS QoS: Bearer Hierarchy

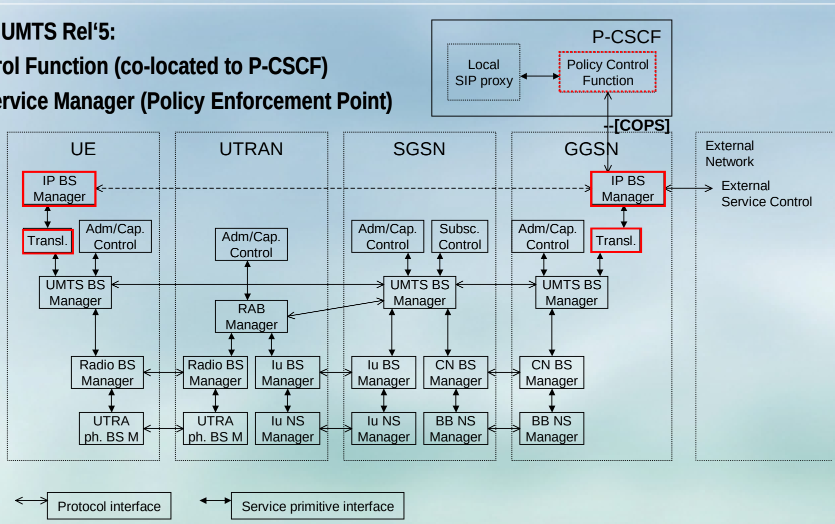


SIEMENS

IMS QoS: 3GPP Architecture

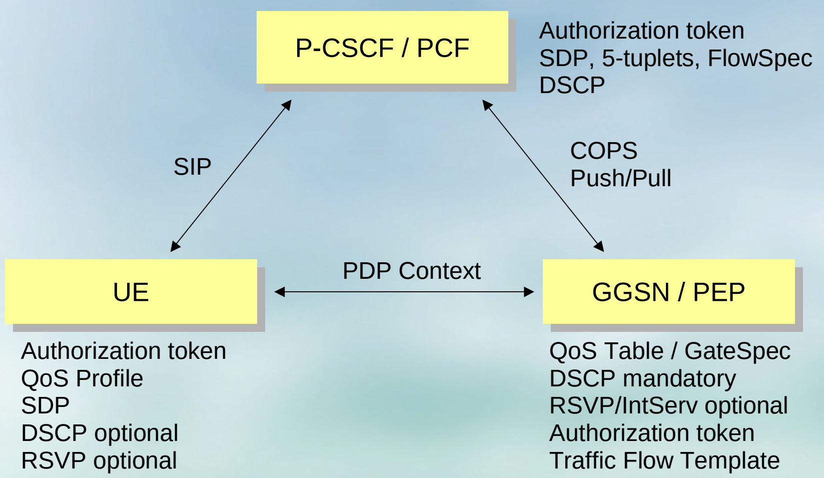
New Entities in UMTS Rel'5:

- **Policy Control Function (co-located to P-CSCF)**
- **IP Bearer Service Manager (Policy Enforcement Point)**



SIEMENS

IMS QoS: Functional Elements



SIEMENS

IMS QoS: Functional Elements (cont`d)

- UE
  - Pre-conditions for SIP QoS Assured Sessions
  - IETF specification of Integration of Resource Management and SIP
- GGSN / PEP
  - DiffServ Edge Function (compliant to IETF), RSVP/IntServ Function (FFS) [optional]
  - RSVP Sender/Receiver Proxy [optional]
  - Service-based Local Policy Enforcement Point
  - Binding Mechanism Handling (PDP Configuration Options)
- P-CSCF / PCF
  - Authorize QoS resources (SDP)
  - PCF => Policy Decision Point for service-based local policy control
  - PCF exchange authorization information with GGSN via Go interface
  - P-CSCF (PCF) final decision on enabling and disabling the allocated QoS
  - Session release, P-CSCF (PCF) shall revoke the resource authorization
  - Binding Mechanism Handling (generate an Authorization Token)

SIEMENS

IMS QoS: SDP Descriptions

SIP-Layer (P-CSCF)

```
...
c=IN IP4 192.141.10.188
b=AS:64
m=audio 29170 RTP/AVP 3 96 97
a=rtpmap:96 G726-32/8000
a=rtpmap:97 AMR
a=fmtp:97 mode-set=0,2,5,7; maxframes=2
m=video 51372 RTP/AVP 34
a=fmtp 34 SQCIF=2/MaxBitRate=500/SAC AP
m=application 32416 udp text_chat
...
```

Flow / Flow / Session

- IP flow 5-tuples
- Flowspec (RSVP)
- DSCP

Mapping by
- Calculation?
- Codec tables?

IP-Layer (GGSN)

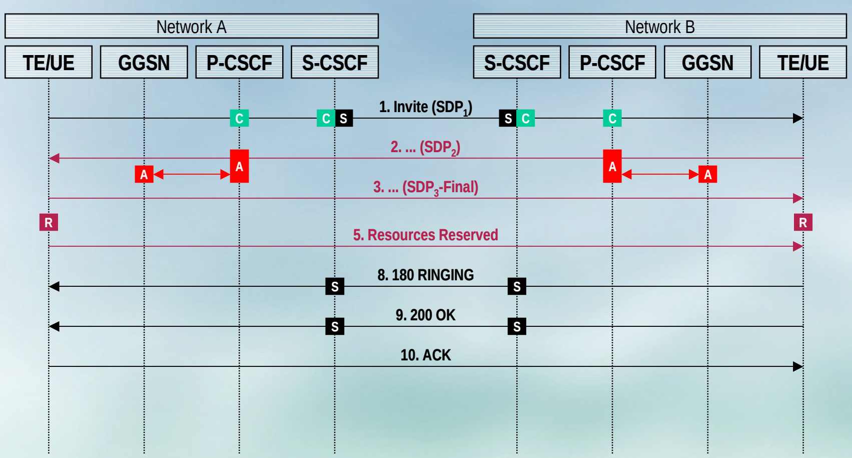
5 - tuples:
- Source Address
- Source Port
- Destination Address
- Destination Port
- Protocol

Flowspec:
- Token rate [r]
- Bucket depth [b]
- Peak rate [p]
- Minimum policed unit [m]
- Maximum packet size [M]

SIEMENS

IMS QoS: SIP/SDP Call Flow (3GPP)

- C Codec Reduction
- S Service Control
- A Res. Authorization
- R Res. Reservation



SIEMENS

Agenda (IMS)

- Introduction to IP Multimedia Subsystem (IMS)
  - Evolution of mobile networks
  - Motivations for the IMS
- Session Initiation Protocol (SIP)
- IMS Architecture overview
  - Registration
  - Session control
  - Interworking with PSTN
  - Conferencing
  - Services
  - QoS concept
- **Summary**

© Siemens AG, WPMC01, 9.9.01

SIEMENS

Summary (IMS)

- IP Multimedia subsystem is standardized by the 3GPP as part of UMTS Rel 5
- IMS is a control infrastructure and provides
  - Secure authentication and service authorization
  - Session control for packet-based connections
  - Interworking with PSTN/2G networks
  - Conferencing
  - Standardized and secure interfaces to applications
- Key benefit
  - Secure infrastructure and control for 3G data, real-time and integrated real-time/voice services.

© Siemens AG, WPMC01, 9.9.01

SIEMENS

Agenda

- Intro: IP Protocol Family & IETF Standardisation
- Part I: Internet Evolution, Internet-on-Air
  - Principles & Architecture
  - Mobility Support by Mobile IP
  - Quality of Service concepts
- Part II: Mobile Network Evolution, IP Based Multimedia Subsystems (IMS)
  - Evolution/Motivation; Session Initiation Protocol
  - IMS Architecture, Registration, Session Control
  - Interworking, Conferencing, QoS
  - IMS Demonstrator
- Protocol Enhancements: Robust Header Compression, Wireless TCP
- Summary, Questions & Answers

SIEMENS

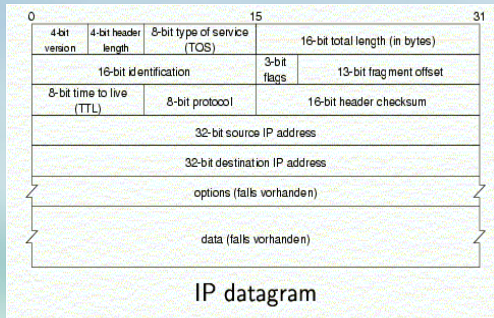
Protocol Enhancements: Motivation

- Wireless links tend to show poor performance
  - Large delays
  - Low throughput
  - Bit errors / packet losses due to radio transmission
- Protocols in IP family not originally designed for such links
  - Increased volume due to headers
  - Deficiencies of TCP flow control
  - ... many more (e.g. applications HTTP→WAP)
- Protocol Enhancements are required, two examples discussed here
  - Robust Header Compression (RoHC)
  - Enhancements for Wireless TCP

SIEMENS

Robust Header Compression (RoHC)

- Motivation
  - IP voice packets: header 40/60Bytes, average payload 25Bytes
  - TCP ACK packets: header 40/60 Bytes, payload often 0Bytes
- Data in many header fields ...
  - ... hardly ever changes e.g. source/destination address within same IP flow
  - ... or changes in a regular pattern
- Idea: reduce header length by compression, e.g.
  - differential encoding of fields
  - and/or variations of Huffman compression
- Compression can be applied to several protocol headers, e.g. RTP/UDP/IP



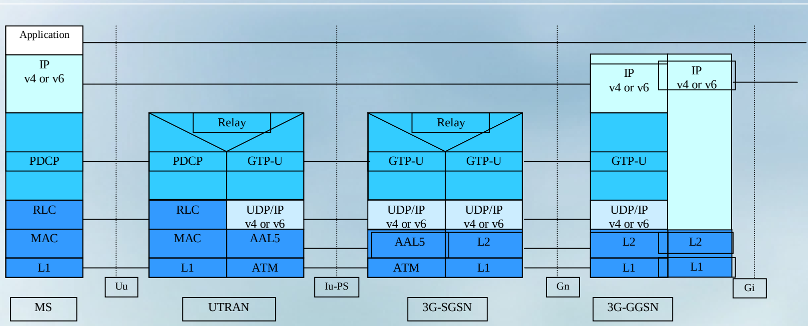
SIEMENS

Robust Header Compression (RoHC)

- Synchronized compression context required in compressor and decompressor
- Lost packets →Synchronization disturbed
  →Additional mechanisms for context synchronisation required: Robustness
  - Error detection by Cyclic Redundancy Codes (CRC)
  - Loss detection through sequence numbers

  Reduced compression efficiency price for error robustness
- Current RoHC methods: 40 Bytes RTP/UDP/IP header →on average 1 or 2 bytes

RoHC in UMTS

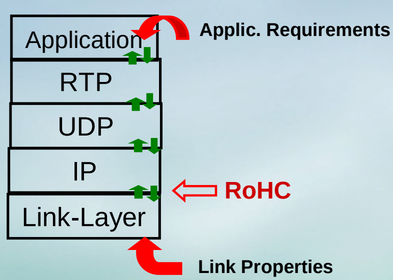


- RoHC optional part of Packet Data Convergence Protocol (PDCP) → headers compressed only over radio link
- In principle compression already in GGSN possible, but
  - Flow identification/separation necessary
  - Large number of flows (up to 10^4 active flows)

RoHC: Ongoing Work

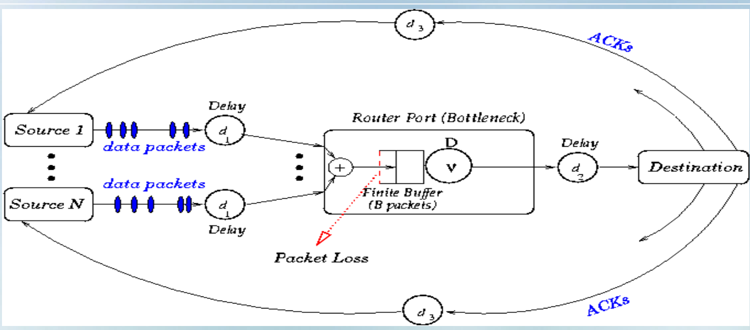
- Application of RoHC methods for SIP compression
  - Compression of whole SIP messages
  - Goal: Reduction of call-setup delay
    (SIP message up to several thousand Byte)
- Optimized use of Compression
  Trade-off: Data-Volume vs. Error Robustness on
  - Application Layer
  - RoHC Layer
  - Link-Layer

  → Optimization across whole protocol stack required



SIEMENS

Protocol Enhancements: Wireless TCP



- End-to-end flow control using ACK packets
- Trigger events: duplicate ACKs and timeouts
- Problem: TCP flow-control designed for congestion avoidance in wired networks
  → can be counter productive for wireless links (long round-trip times, packet loss)

SIEMENS

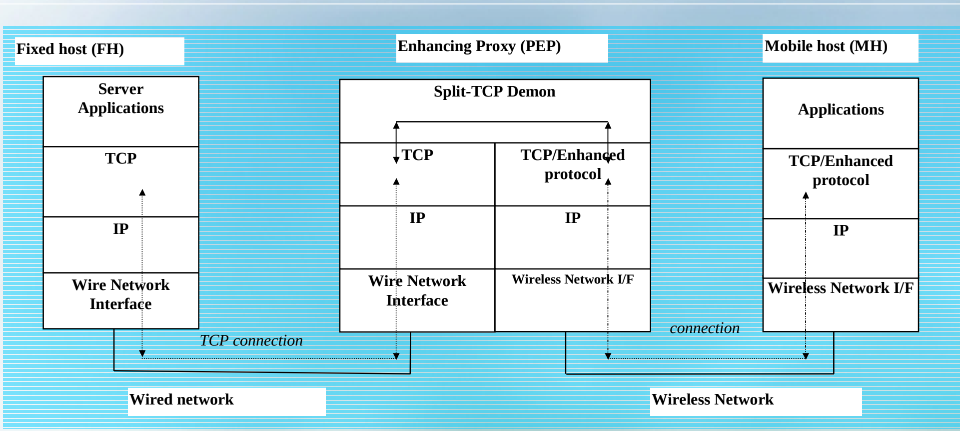
Wireless TCP: Common Approaches

- Split-Connection Approach
  - End-to-End flow control terminated before wireless link
- Link-Layer Approach
  - Local Retransmission of lost packets
  - Hide losses from sender
- Explicit Notification Approach
  - Explicitly notify TCP sender of the condition of the network / type of the loss
- End to End Aproach
  - Enhance TCP Protocol Stack at Sender and Receiver to achieve better throughput

[Source: G. Reuss]

SIEMENS

Wireless TCP: Split Connection



- Proxy is located between the 2 end-hosts (i.e. MH & FH) to split the TCP connection into 2 parts

[Source: G. Reuss]

SIEMENS

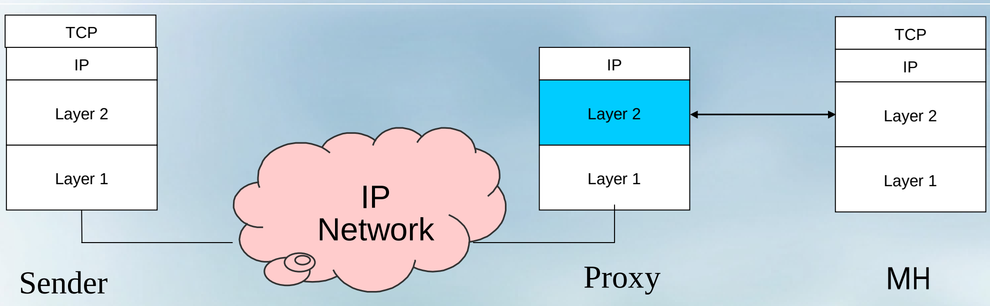
Wirless TCP: Split Connection (cont`d)

- Advantages
  - Shields the end-host in the wired network from the wireless network characteristic
  - Wireless Local Recovery by Proxy
  - Conservation of bandwidth of the wireless link
  - Reduced header size for optimized transport protocol over wireless link
  - Smaller and simpler wireless protocol between MH and Proxy
- Disadvantages
  - Modifications required at MH
  - No end-to-end TCP semantics
  - Not usable with IPSEC, since access to the TCP header needed
  - Requires buffer management at Proxy

[Source: G. Reuss]

SIEMENS

Wireless TCP: Link-Layer Approach



- Proxy detects losses over the wireless link
- Proxy does local retransmission before the sender timeouts. Hides the wireless losses from the Sender

[Source: G. Reuss]

SIEMENS

Wirless TCP: Link-Layer Approach (cont`d)

- Advantages
  - No modification to end hosts
- Disadvantages
  - TCP-aware link layer solutions cannot be used with IPSec
  - Sender may not be fully shielded from wireless losses
  - TCP End-to-End retransmission scheme and Link-Layer retransmissions
    → possibly duplicate retransmissions

[Source: G. Reuss]

SIEMENS

Wirless TCP: End-to-end approach

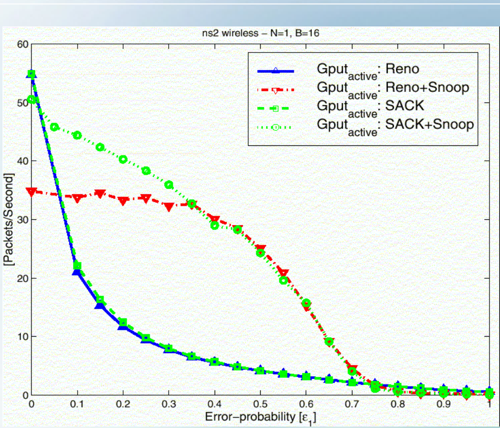
- TCP Protocol Stack at Sender and Receiver enhanced
  e.g. SACK, FACK, D-SACK, Eifel
- Possible enhancements
  - Differentiate Losses
    e.g. no slow-start for wireless losses
  - Efficient Utilisation of Bandwidth
    e.g. no initial slow-start
  - Detection of Multiple Losses
- Advantages
  - End-to-End semantics and layered architecture of network protocols are preserved
  - IP packet encryption can be used
- Disadvantage
  - Modification at end host

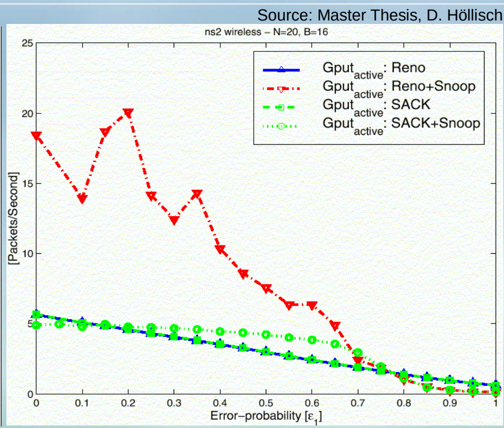
[Source: G. Reuss]

SIEMENS

Wireless TCP: Performance Comparison (ns simulation)

Source: Master Thesis, D. Höllisch





Single source scenario with burst errors on wireless link (ε_1=1 ≅ ca 28% packet loss)

→ Snoop (Split-TCP) together with SACK (end-2-end approach) provides best goodput

Congestion scenario (20 ON/OFF TCP sources) with same wirless link model:

→ Combination SACK with Snoop shows much lower goodput than Snoop by itself

SIEMENS

Agenda

- Intro: IP Protocol Family & IETF Standardisation
- Part I: Internet Evolution, Internet-on-Air
  - Principles & Architecture
  - Mobility Support by Mobile IP
  - Quality of Service concepts
- Part II: Mobile Network Evolution, IP Based Multimedia Subsystems (IMS)
  - Evolution/Motivation; Session Initiation Protocol
  - IMS Architecture, Registration, Session Control
  - Interworking, Conferencing, QoS
  - IMS Demonstrator
- Protocol Enhancements: Robust Header Compression, Wireless TCP
- Summary, Questions & Answers

© Siemens AG, WPMC01, 9.9.01