Summary: Mobile Services

Abkürzung

UE: User Equipment
MS: Mobile Station
MT: Mobile Terminal
UE = MS = MT

MN: Mobile Node
CN: Correspondent Node
CS: Circuit Switched
PS: Packet Switched

URL: Uniform Resource Location
URN: Uniform Resource Name
URI: Uniform Resource Identification (either URL or URN)

OMA: Open Mobile Alliance
CC/PP: Composite Capabilities and Preference Profile
UAProf: User Agent Profile
PPG: Push Proxy Gateway
PI: Push Initiator
OtA: Over the Air
SI: Service Indication

Network Technologies

ISDN: Integrated Services Digital Network
GPRS: General Packet Radio Service
GSM: Global System for Mobile Communications
EGSM: Extended GSM
EDGE: Enhanced Data Rates for GSM Evolution
PSK: Phase Shift Keying
UMTS: Universal Mobile Communication System
HSPA: High Speed Packet Access
HSDPA: High Speed Downlink Packet Access
LTE: Long Term Evolution
WiMAX: Worldwide Interoperability for Microwave Access
IMS: IP Multimedia System

FDMA: Frequency Division Multiple Access
TDMA: Time Division Multiple Access
CDMA: Code Division Multiple Access

OFDM : Orthogonal frequency-division multiplexing (multicarrier modulation)
MIMO: Multiple Input Multiple Output (new antenna Technology (WiMAX)

LA: Location Area
RA: Routing Area
URA: UMTS Registration Area

Protocols

IP: Internet Protocol
PDP: Packet Data Protocol
GTP: Gateway Tunneling Protocol
GTP-U: GTP - User Plane
TCP: Transmission Control Protocol
TCP-mP: TCP Mobile Profile
UDP: User Datagram Protocol
WAP: Wireless Application Protocol
PAP: Push Access Protocol
SIP: Session Initiation Protocol

Data and Services/Tools/Numbering

SIM: Subscriber Identity Module
IMSI: International Mobile Subscriber Identity
TMSI: Temporary international mobile Subscriber Identity
MSRN: Mobile Station Roaming Number
MSISDN: Mobile Subscriber ISDN Number
IMEI: International Mobile Station Equipment Identity
LAI: Location Area Identifier
CI: Cell Id
RAND: Random Number
SRES: Session Key
SAT: SIM application Toolkit
USAT: UMTS SAT

P-TMSI: Packet TMSI
RAI: Routing Area Identifier
APN: Access Point Name

CoA: Care-of-Address

WML: Wireless Markup Language
HTML: Hypertext Markup Language
TLS: Transport Layer Security

WURFL: Wireless Universal Resource File

Network Components

GSM

BSS: Base Station Subsystem
BTS: Base transceiver Station
BSC: switching Center

MSC: Main switching Center
HLR: Home Location Register
VLR: visitor Location Register
AuC: Authentication Center
EIR: equipment Identity Register
NPDB: Number Portability Database

GPRS

GGSN: Gateway GPRS Support Node
SGSN: Serving GPRS Support Node

UMTS

NB: Node B
RNC: Radio Network Controller
USIM: UMTS Subscriber Identity Module

LTE:

SAEGW: System Architecture Evolution Gateway
MME: Mobility Management Entity

SSP: Service switching Point
STP: Signalling Transfer Point
SCP: Service control Point
SGSN: Serving GPRS Support Node
GGSN: Gateway GPRS Support Node
EGPRS: Enhanced General Packet Radio Service

MME: Mobility Management Unit

IMS

CSCF: Call Session Control Function
HSS: Home Subscriber Server
MRF: Media Resource Function
MGW: Media Gateway Function
MGCF: MGW Control Function

Chapter 1 – Overview and Introduction

Ubiquitous Computing

Interconnecting computing devices with environmental objects

Personal Mobility

- Key functions: authentication mechanism
- Means that users can access their services according to their subscription from different
- devices and device types
- User is available via her/his telephone number or email address
- User profiles and services are available across device boundaries

Service Mobility

Enables usage of tailored and personalized services even if the user is roaming to
foreign networks

Session Mobility

Allows to interrupt sessions and to resume them later possibly from another terminal or another network

Mobility Classification

Micro Mobility: Change Access Device in a Access Network (Location Update Freqency High)

Marco Mobility: Change access Network

Global mobility: Change Core Network (Distance Far)

Protocol Stack

Please Do Not Throw Salmi Pizza Away
Physical Layer
    transformation of bit stream into signal and signal to bit stream
Data Link Layer
    Point2Point and Point2 Multiple Point connection
    Medium Access, correction of transmission errors
Network Layer
    Connection between two entities over many intermdiate systems
    Routing
    Addressing

Example IP
Transport Layer
Establishment of an end to end connection
QoS, Flow and congestion control
Example TCP / UDP
(Security Layer)
(Presentation Layer)
Application Layer
Protocols design for fulfilling communication needs of an application
Example HTTP

Chapter 2: Mobile Networks

Infrastructure vs Ad-hoc Networks

Comlexity resides at the infrastructure site whereas the terminal can remain comparatively simple

Access Network:
Subnetwork that comprises serveral access points/base stations
Core Network:
backbone that interconnects serverall access networks and that is under sole controle of a mobile network operator
Handover:
changing the assignment of a mobile terminal from one access point to another
Paging:
procedure initialized by the infrastructure to determine the access point/base
station a certain terminal is attached to
Location update:
procedure initialized by a mobile terminal to notify the network about the current access point/base station it is connected to
Roaming:
use of services in a foreign network, i.e., the network of a mobile network operator the subscriber has not contract with

2G Networks

GSM900 [14.4kbps]

EGSM
GSM1800/1900
GPRS <- First Packet Switched/ introduced a second core network for packet switched communication [50-60kbps] uses TDMA

EDGE (uses 8-PSK modulation) [48kbps]
EGRPS

GSM ciphering between UE and BSC

GSM Access Network

Base Station Subsystem (BSS)

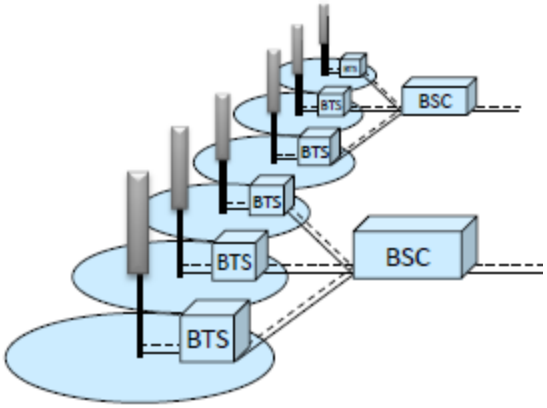
- Consists of a Base Station Controller and one or more Base Transceiver Stations

Base Transceiver Station (BTS)

- Defines a signle radio cell with the radius between 100m and 35km
- De-/Modulation
- Media Access control
- (just an execution Node)
- error correction
- de-/ciphering

Base Station Controller (BSC)

- Controls one or mutiple BTS
- Performs essential control functions and coordination between BTS's
- Power Controls, Hand Over



GSM Core Network (GERAN)

Mobile Switching Center (MSC)

- Performs all switching functions (e.g. routing path search, signal routing, service feature processing)
- Handover between BSC's
- Support of service features (e.g. Conference Call, Call Forwarding)
- Uses Zeichengabe Nr 7 interchange between MSC's
- managing the user Channel

Gateway MSC

- passing of voice traffic between fixed and mobile networks

- Required as access to GSM network, because fixed network is unable to connect an incoming call to the local target MSC (due to its inability to interrogate the HLR)

Home Location Register (HLR)

- central database that stores permant and temporary information of the subscribers associated with the network

Visitor Location Register (VLR)

- Database containing distributed nodes, being responsible for a certain coverage area
- Contains information about subscribers currently physically staying in the associated coverage area
- Usually combined with an MSC
- copy of part of the HLR

Authentication Center (AuC)

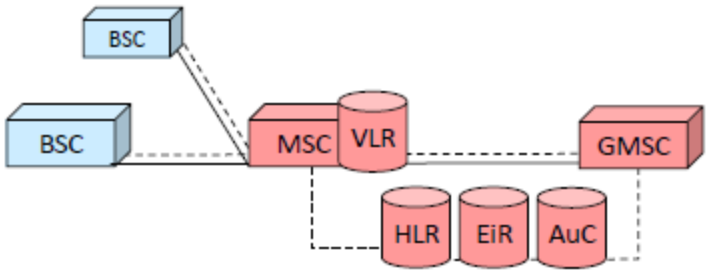
- Generates key for authentication and encryption
- Used for protecting user identity and data transmission

Equipment Identify Register (EIR)

- Stores all user equipment identification registered for this network
- stores blacklists graylists for the equipment serial Numbers not IMSI

Other Components:

- SMS/WAP Gateway



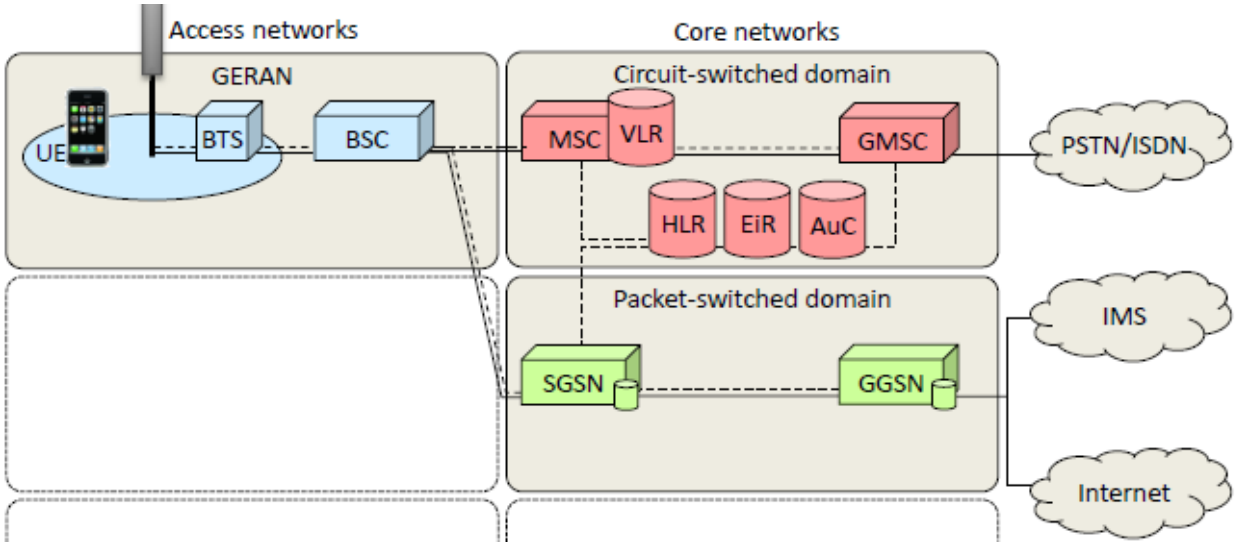
GPRS Network Extension for GSM

Gateway GPRS Support Node (GGSN)

- Gateway access to the Internet

Serving GPRS Support Node (SGSN)

- Connects the radio access network to the GPRS/UMTS core
- Tunnels user sessions to the GGSN
- Packet-switched counterpart to MSC



3G Networks

UMTS [100kbps - 2Mbps]

Medium access: CDMA Direct Sequence with a channel bandwidth of 5 MHz and 3.84 Mbps chipping rate

- New Access Network but GPRS Core Network.
- new frequency, New Antennas
- Voice and Data Traffic should go the Same Way
- 5MHz

HSDPA and HSPA
Advanced modulation schemes for UMTS networks

UMTS Terrestial Access Network (UTRAN)

Node B (NB)

- Counterpart to GMS's BTS
- Can handle serveral antennas
- Uses CDMA instead of GSM FDMA/TDMA
- UE is usally connected to serval NB's

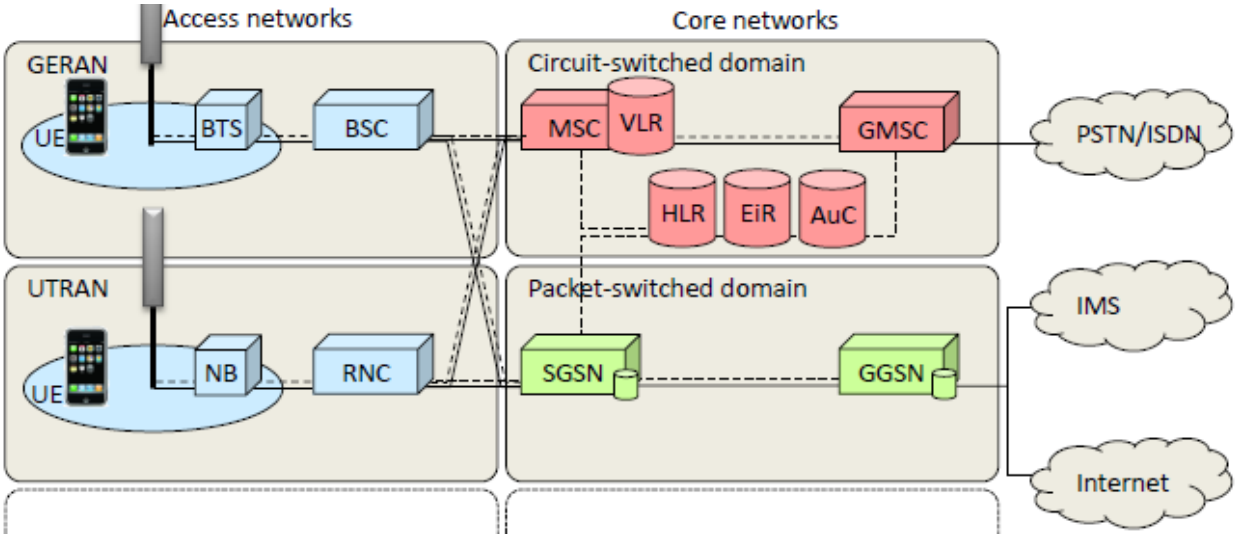
Radio Network Controller (RNC)

- Counterpart to GMS's BSC
- Neighboring RNC's are directly connected (more complex but better handover control
- Serves Serveral NB's and connected to circuit and packet switched core network

UMTS Subscriber Identity Module (USIM)

- All features of conventional SIM
- Security features: integrity and mutual authentication

- UMTS SIM Application Toolkit (USAT) extension of sat, addtional computation power, more storage and new capabilities



4G Networks

LTE [170Mbps - 1Gbps (future)]

- first installation 2011
- introduces mutlicarrier modulation (OFDM) and new antenna technology (MIMO)
- Common Gateway for all access technologies
- IP-based protocols on all interfaces
- Split in the control and user plane between MME and SAEGW
- Optimized Architecture for the user plane: only two node types (eNB and Gateway)

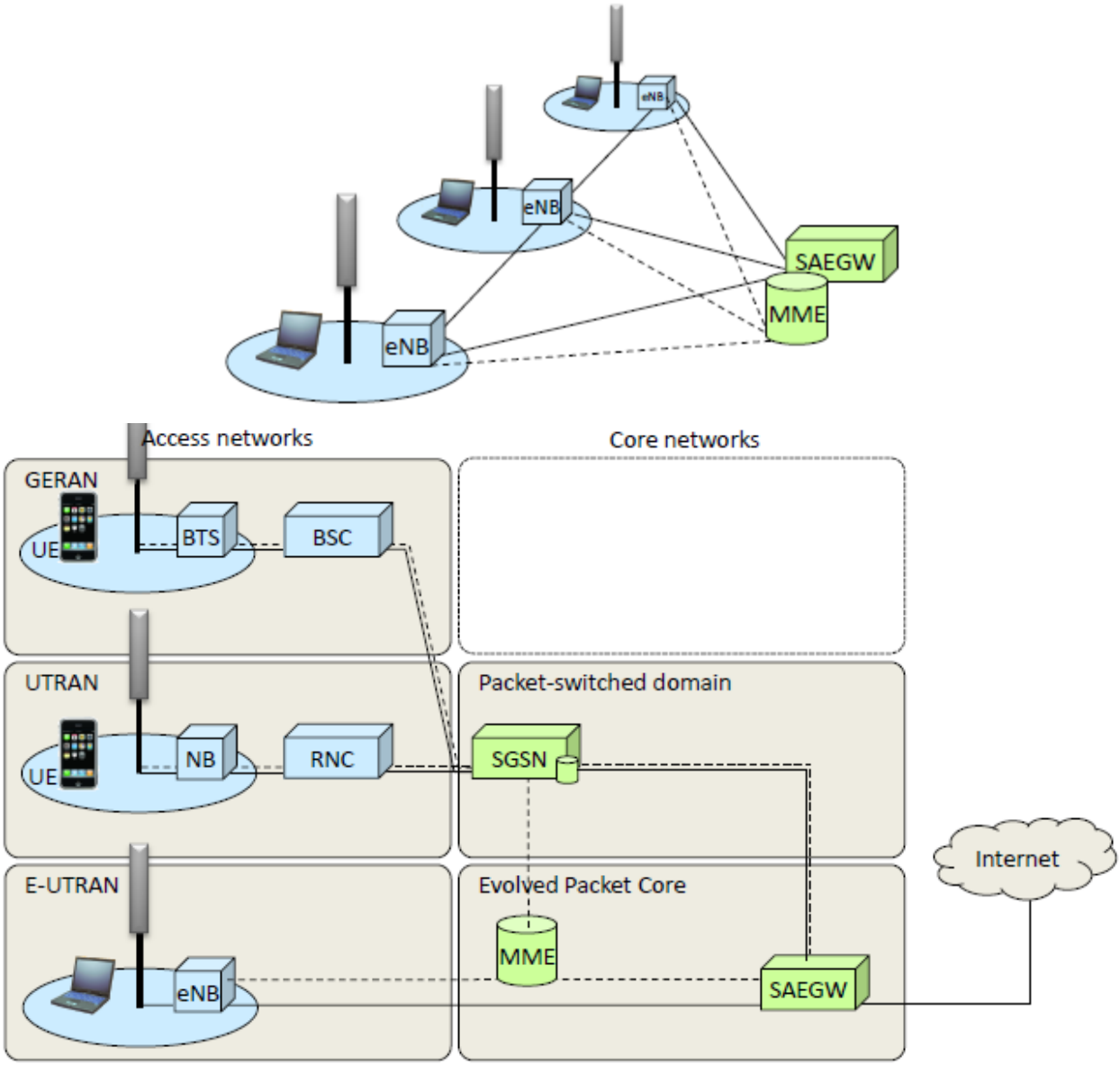
Network Components

System Architecture Evolution Gateway (SAEGW)

- Routes and forwards User Data packets
- Acts as mobility anchor for the user plane during inter-eNB handover and as anchor for mobility between LTE and other 3GPP technologies
- Terminates downlink data path for idle UE's and triggers paging

Mobility Management Entity (MME)

- tracking of idle UE's
- paging procedure and retransmission
- handover control
- Authentication
- Bearer activation and deactiviation



WiMAX

Kabelose Übertragungstechnology für verschiedene Szenarios

- Alternative für die letzte Meile zum Anwender
- Wlan mit dem Internet zu verbinden
- Portable Connectivity
- enables large range mesh networks

Fixed WiMAX

point to point
fixed only suited line of sight
Transmission Range bis zu 70km
Data rates bis zu 134Mbps

Nomadic WiMAX

Point to Multipoint
Not line of sight transmission

Mobile WiMAX

Support for Mobile SUbscribers
Serves customers traveling at pedestrian speeds
Hard Handover
Mobile Access Mode -> bis 125kmh und soft handover

WLAN WiMAX are Pure access Technologies
WiMAX fills the gap between WLAN and cellular Networks

DataRates: WLAN > WiMAX > UTMS > GSM/GPRS
Mobility: WLAN < WiMAX < UTMS < GSM/GPRS

Local and Personal Area Networks

WLAN WiFi

Only access technology
Covers only physical and medium access layer
No Mobility Support

Wifi Stack

Application
TCP
IP
802.11 MAC
802.11 PHY

Infrastructure Versus Ad-hoc WiFi

Infrastructure

- transmission only between device and access point
- used to get services (e.g. Internet)

Adhoc

- Direct Transmission between devices
- coverage between 30 and 300m

Bluetooth

Piconet

- very small net between devices
- Consists of Master Slaves
- slaves only talk to master

- master can have up to 7 slaves

Scatternet

- Group of linked piconets joined by common devices

Chapter 3 – Moblity Management

Consits of Handover and Location Management

Handover Management

Verbindung halten wenn Nutzer Funkzellen verlassen

Gründe

- Signal fällt unter einen bestimmten grenzwert
- Kapazität der Zelle erschöpft
-

Wird vom Endgerät oder von der Base Station ausgelöst

Genereller Prozess: Messung -> Entscheidung -> Durchführung

Messung

Gemessen wird:

- Signalstärke zwischen aktueller Base Station sowie auch zu benachbarten Basestations
- Qualität des Signals (Error Rates, Rauschen)
- Entfernung

Messergebnisse werden zwischen Endgerät und Base Station ausgetauscht
Handover wird verhindert, solange das Signal der Aktuellen BS noch stark genug ist

Entscheidung

Endscheidungs parameter sind Grenzwert und Hysterese (Spielraum)

RSS with Threshold

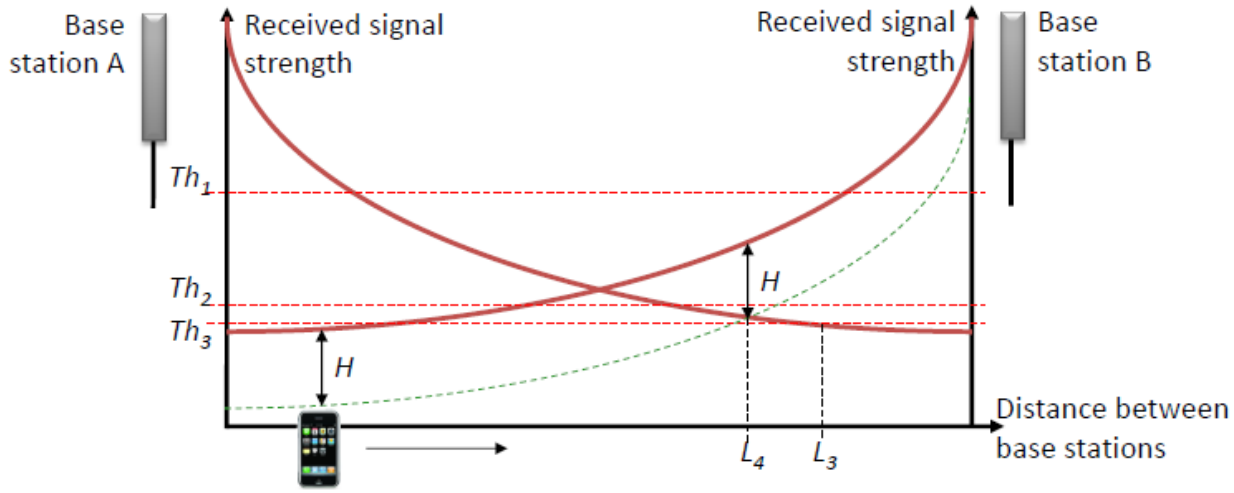
Signal der aktuellen BS weniger als ein Grenzwert ist und das Signal der Nachbar BS stärker ist!

RSS with Hysteresis

von A zu B BS wird nur gewechselt wenn das Signal von B um einen Wert H stärker ist als A

RSS with Threshold and Hysteresis

Handover wenn Signal unter Grenzwert fällt und die das Signal der Ziel Basestation um H stärker ist als das aktuelle Signal
-> No Ping Pong Effect, And no Handover is Signal is strong enough



Durchführung

Handover signalgebung
Frequenz belegung

Hard Handover

Unterbrechung bevor Handover
Endgerät kommuniziert nur mit einer BS!
Verwendet bei FDMA und TDMA

Soft Handover

Keine Unterbrechnung beim Handover
Neue Verbindung wird aufgebaut bevor alte abgebaut wird
Alte verbidung wird getrennt sobald die neue Aufgebaut ist
CDMA when aneinandergrenzende Zellen die gleichen Frequenzen verwenden.

Other Handover Types

- **Intra**- Frequency
  - ➢ same frequency other code
- **Inter**- Frequency
  - ➢ changing frequency
- Inter-system
  - ➢ wechsel zwischen Radio Access Networks (GSM UTMS)

Network-Controlled Handover (NCHO)

Network decides when handover will happen.
Mobile Terminal macht keine Messungen
Not Handover Signalling über die Luft, kabel only mit anderer BS
Dauert 100-200ms (daten übertragung channel und netzwerk schaltung wird mitübertragen.

Mobile-assisted Handover (MAHO)

Endgerät misst kontinuirlich signal stärke von umliegenden BS und informiert die aktuelle BS
Network entscheided ob handover oder nicht
Handover management über dem luft weg
dauert 1 sekunden, durch das ganze hinund her senden von messungen

Mobile-Controlled Handover (MCHO)

Endgerät misst und entscheidet ob es handover macht
sehr schnell 0.1s

Location Management

Mechanismen um benutzer im fall eines Anrufs/Nachricht zu lokalisieren
Für effizientes Location Management werden Location Areas eingesetzt
Zwei grundlegende Elemente: Location Update und Paging
Location Update: Endgerät informiert Netzwerk über seine position
Paging: Broadcast nachricht vom Netzwerk um die aktuelle Zelle des zu findenen Users herauszufinden

Paging Only Location Management

Endgerät wird gepaged wenn ein Anruft eingeht.
Location Update vom Endgerät zur BS ist nicht nötig
Muss für jede SMS Anruf Data packet erneut durchgeführt werden, großer overhead
-> Außerdem delay!

Location Update Location Management

Jedes mall beim überschreiten von Zellen Grenzen wird ein Locaiton Update ausgelöst
Paging wird nicht benötigt
Belastet Endgerät Energy verbrauch
Database Update overhead
High Signalling overhead due to many terminals

Location Areas

Mehrere Zellen werden zu einer LA verbunden
In der Location Area in der sich das Endgerät befinden wird Paging gestartet
Location is stored in database

Design of Location Areas: Goal: Minimizing location Management Cost (LU+ paging traffic and processing)

Static Location Update Schemes

Always Update

- User updates always when he moves into a new cell
- No paging needed
- huge overhead

Never Update
- Excessive paging needed

Reporting Cells
- Only updates when visiting predefined reporting cells
- needs paging in neighboring cells

Forming LAs
- Updates when in a new LA
- paging only in LA

Dynamic Location Update Schemes

Selective LA Update
- skip certain LAs if user spends short period of time in those LAs

Time-Based
- Updates in constant time intervals
- can be optimized per user

Profile-based
- Network maintains a profile for each user
- most likely LAs in a list
- profile update from time to time

Movement-based
- Updates after number of boundary crossings
- optimized per user and call arrival

Distance-based
- Update when he moved away a certain distance from the last cell

Paging Strategies

Simultaneous Paging
- all cells of a LA paged simultaneously
- used scheme in current networks

Shortest-distance-first
- start with the last cell he was found in and than go to further cells

Sequential Paging
- user is paged in sub-groups of the LA in sequentially

Velocity Paging
- use user velocities at the moment of LU
- paging area dynamically generated from the time and velocity

GSM Location Management

Different location management schemes for GSM and GPRS
GSM: Hybrid Location Updating

GPRS: smaller location areas with adaptiev paging/location update

Endgerät erkennt LA ID via LA broadcast, wenn neue LU

Numbering Schemes for PSTN/ISDN

Country Code (3) + National Destination Code (N) + Subscriber Number (15-N)

International Numbering Plan
- SO everybody from all over the world can talk with each other
- 9 Global Areas

National Numbering Plan
- Country specific rules

Basic Numbering in GSM

Personal Mobility: personal phone number independent of the mobile device
- Separation between subcriber and device number

Terminal Mobility: number temporaly attached to local switch

Fucking Numbers

International Mobile Subscriber Identity (IMSI)
- stored in the SIM, HLR, AuC
- used for billing
- Mobile Country Code + Mobile Network Code + Mobile Subscriber Identification Number

Mobile Subscriber ISDN Number (MSISDN)
- Reak Number of subscriber
- subscriber can have serval numbers
- Stored in HLR SIM
- Country Code + National Destination Code + Subscriber Number

International Mobile Station Equipment Identity (IMEI)
- Unique International mobile station identifier
- allocated by the manufacturer
- stored in EIR
- Characterizes mobile station and gives clues of manufacturer and manufacturing date

Location Area Identifier (LAI)
- international unique identification of LA
- regularly broadcasted by the BS

Cell Identifier (CI)
- Unique identification of cell within LA
- Global Cell Identity LAI+CI

Mobile Station Roaming Number (MSRN)
- Temporary Location dependent ISDN Number

- required for routing and MSC identification

Temporary Mobile Subscriber Identity (TMSI)

- used instead of IMSI
- avoids subscriber identification by listening to the radio channel
- is usally changed periodically
- Stored on SIM card and VLR
- Uniquely identify a user bei TMSI and LAI

Who stores what?

HLR

- IMSI
- MSISDN
- MSRN

MSC+VLR

- MSRN
- IMSI
- TMSI
- MSISDN
- LAI

AuC

- IMSI
- RAND
- SRES
- Ki
- Kc

EiR

- White/Gray/Black Lists

BTS

- CI
- LAI

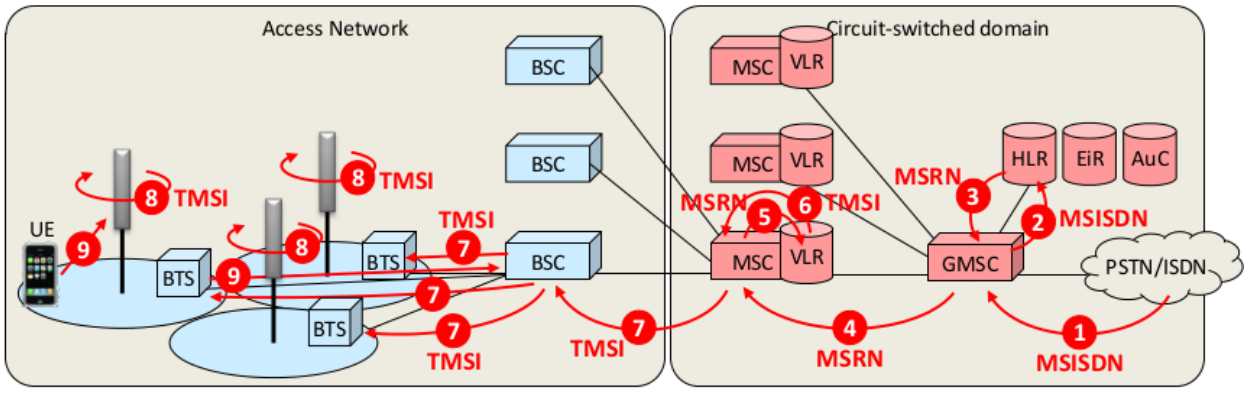
Mobile Station

- IMEI

SIM

- IMSI
- TMSI
- MSISDN

Dilvery of a Mobile-Terminated Call



1. Forwarding to responsible GMSC (based on CC and NDC of MSISDN)
2. Request of Mobile Station Roaming Number, which addresses the subscriber at her/his current MSC
3. Delivery of MSRN
4. Forwarding of call to MSC
5. Request of LAI and TMSI for paging
6. Delivery of TMSI
7. Paging request to all BTSs that belong to the LA referenced by the LAI
8. Paging execution through broadcast of TMSI at the paging channel
9. Paging response

1. MSISDN zu MSRN durch HLR
2. MSRN zu TMSI durch VLR
3. TMSI benutzt für Paging

Location Registration vs Location Update

Location Registration

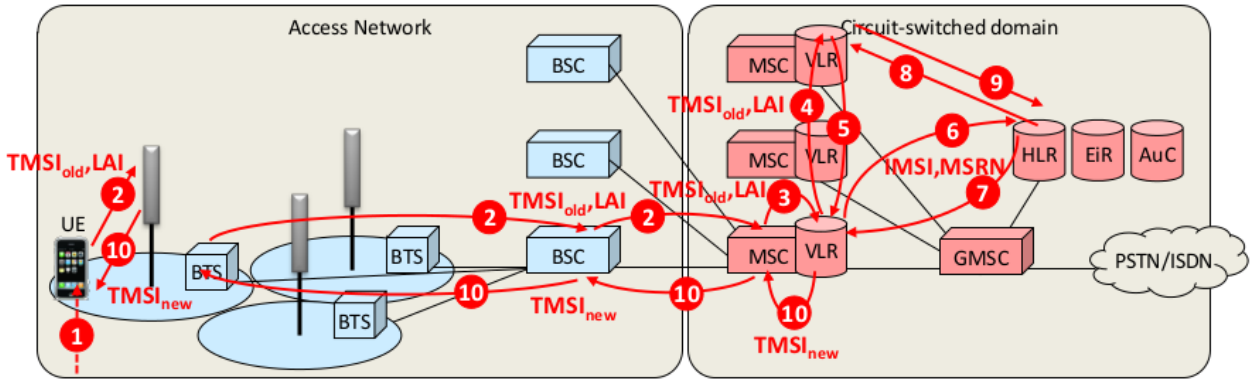
Essenstiell um GSM netzwerk zu nutzen

1. IMSI LAI werden an Netzwerk gesendet
2. Authentifizierung
3. start of Ciphering
4. TMSI (VLR) und MSRN (HLR) wird erstellt
5. Engerät speichert TMSI in der SIM Karte

Location Update

Based on TMSI instead of IMSI!

Location Update Procedure

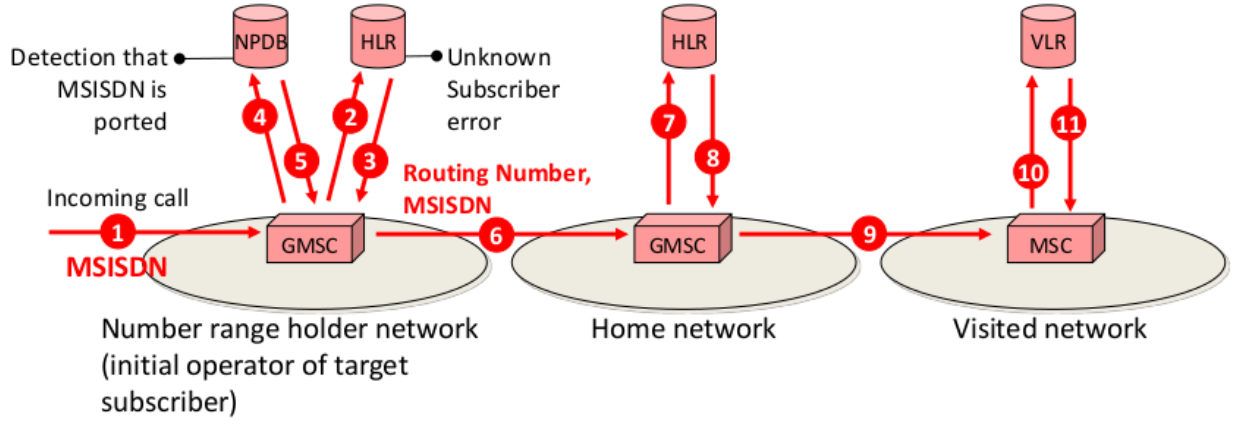


1. Crossing the border of a new LA
2. Location Update request
3. Update Location (contains old TMSI as well as old and new LAI)
4. Request parameters from old VLR (only required if VLR changes)
5. Deliver parameters from old VLR
6. Update location in HLR (only required if VLR changes)
7. Update confirmation
8. Remove parameters in old VLR
9. Remove acknowledgement
10. Location update confirmation and delivery of a new TMSI

1. Bei ankunft in neuer LA
2. Location Update Request mit alter TMSI und LAI der alten LA und neuen LA
3. Parameter aus der alten VLR werden in die neue Kopiert
4. Update des HLR
5. neue TMSI and das Endgerät ausliefern

Number Portability

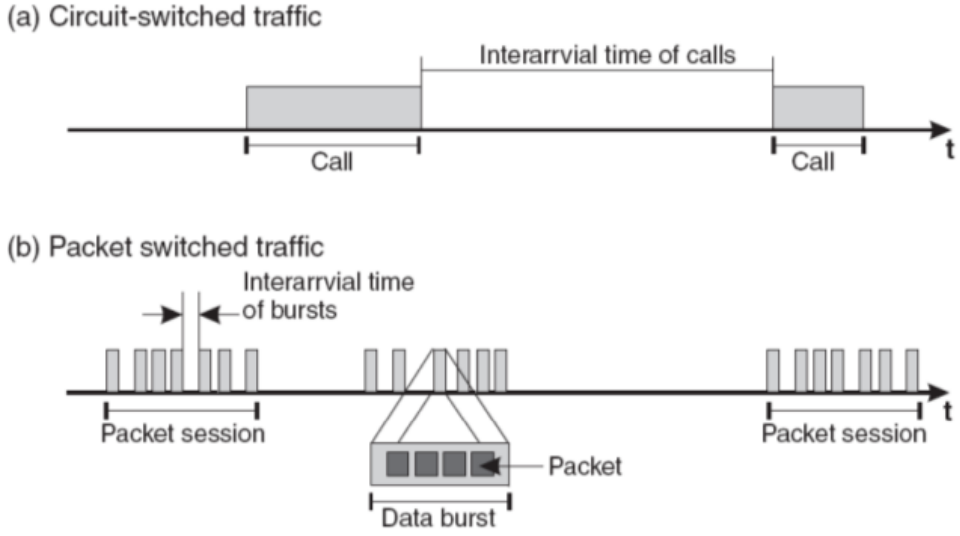
MSISDNs are operator specific could not be kept by user when changing operator
Soll nun aber möglic gemacht werden von den Betreibern
-> geregelt durch neue Datenbank NPDB (Number Portability Database)



GPRS Location Management

Circuit- vs Packet-Switched Traffic

- ➔ Frequency of data bursts much highter than calls in circuit switched mode
- ➔ interarrival time much smaller in packet than circuit switched
- ➔ packet switch more paging requests for each data burst



Routing Areas

Paging of the terminal for every downlink packet = huge overhead
Instead: State Model and Routing Areas
> Consits of serveral cells
> smaller than LAs

State Model

State Transitions are triggered by **Timers, Data Packet Transfer or User Activity**
IDLE
> not reachable in GRPS mode, location mangement ala GSM
READY

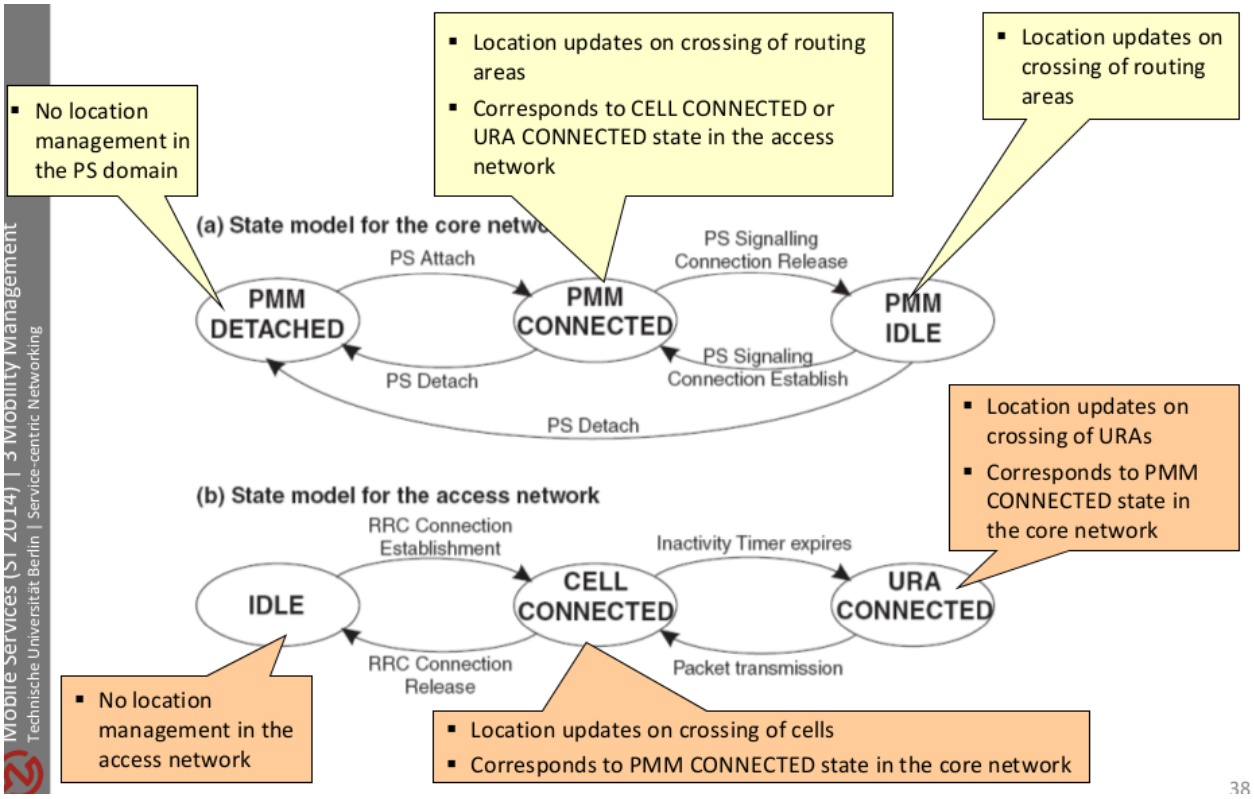
> LU when entering new **cell**
STANDBY
> LU when entering new **RA**

UMTS Location Management

GPRS: location management exlusively controlled in Core Network, Procedures must pass the interface between the Access and COre Network -> High load large delays

UMTS Approach:
Track users of RA basis in the Core Network
Track user of URA (Utran Registration Area) and cells in the access Networks

UMTS State Models



Components Storing Location Data

- ➔ Position eines Endgeräts im Idle Modus ist nicht genau bekannt
- ➔ In Verbindungsorientierten Modus werden Endgeräte nur in LAs getrackt
- ➔ in Packet orientierten Modus hängt die genauigkeit von GPRS/UTMS ab

Components that store location data and the granularity of location:

	MSC/VLR			SGSN		UTRAN
	GSM	GPRS	UMTS	GPRS	UMTS	UMTS
Cell	no	no	no	yes	no	yes
URA	—	—	no	—	no	yes
Routing area	—	no	no	yes	yes	no
Location area	yes	yes	yes	no	no	no

LTE Location Mangement

- back to the roots, mutlilocation like in UTMS to complex
- LA now known as Tracking Areas (TA)
- TA Updates report to MME (Mobile Mangement Entitiy)
- Self-Organized Realignment of TAs possible

LTE State Model

LTE-Active
> Network knows in which **cell** the MS is
> no paging or TA Updates needed
LTE-Idle
> Network knows in which **TA**
> only updates when crossing TA border
LTE-Detached
> Network has no information about the user
> no transfer possible

Self organized Realignment of TAs

find balance between paging and updates
network permantly optimizes TA considerung movement and data exchange

Chapter 4 - Mobile Internet

Problem Statement

IP Header:

- Type of Service
- Total Length
- TTL
- Header Checksum
- Fragnemnt ffset
- Version
- Source / Destination Address
- Payload

Attributes

- Packets can be losts
- arrival order may change
- packest can be send without establishing a connection
- each data packet contains a header
- different routes possible

Three Classes of IP Networks A B C (C Smallest)

Original IP does not support Mobility. User has to change his IP address when moving to a new network

> TCP does not survives any address change
    Solution: Inform all communication partners
> Mobile hosts acting as servers are not reachable after address change
    Solution#1: Use of dynamic DNS for updating logical and IP address
    Drawback: DynDNS not for frequent updates

    Solution#2: dedicated routes for mobile ndoes
    Drawback: does not scale

Mobile IP

Components of Mobile IP:

- Mobile Node (MN)
- Correspondent Node (CN)
- Home Network
- Foreign Network
- Foreign Agent
    - forwards packets to the MN
- Care of Address (CoA)
    - Adress associated with the FAof the foreign Network
    - Ip Packets for MN are delivered to the CoA and then forwarded to the MN

Basic Procedure
CN wants to send to MN
CN sends to Homework/Agent of the MN
HA packt es in neuen umschlag für den FA wo sich der Mobile Node befindet
FA packt aus und sendet an den MN
MN replied direct zu CN Ohne umweg über sein HN

Once an MN has deteced that it entered a (new) foreign networok it has to register with the FA and alert the HA
> Detects by Agent Advertisement

> Agent Solicitations (bitten, ansuchen, werben)

Wenn der weg zum HA sehr weit ist macht es keinen sinn immer über die HA zu gehen. Daher dem CN mitteilen wo sich der MN befindent durch Binding

Mobile IPv6

allows node to remain reachable while moving in the IPv6 internet

Diff zu v4

- no need for special Foreign agent routers
- Route optimization is part of the protocol
- using ipv6 routing header to reach MN in foreign network
- Mobility header

Network Layer Support in GPRS/UMTS

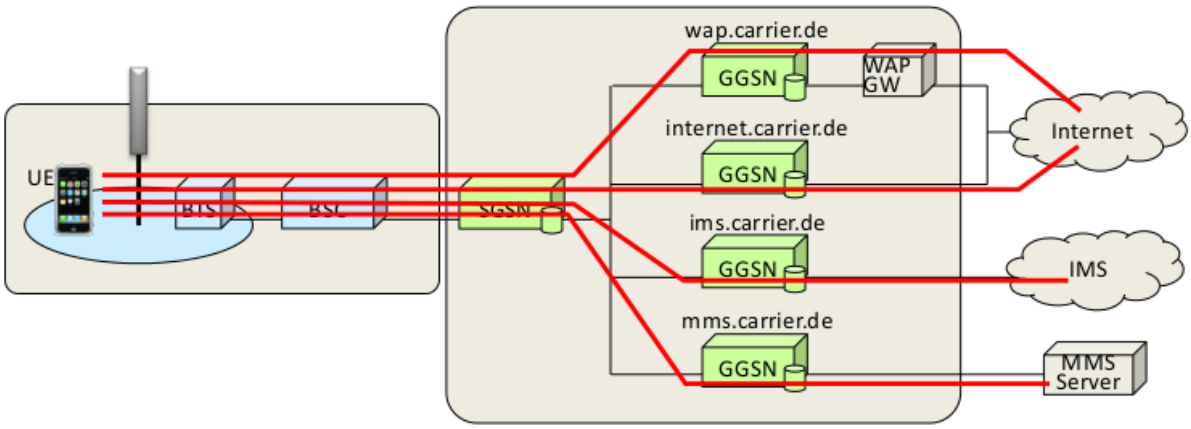
1. GPRS Attach
2. Activation of PDP Context
3. Data Transfer

PDP Context

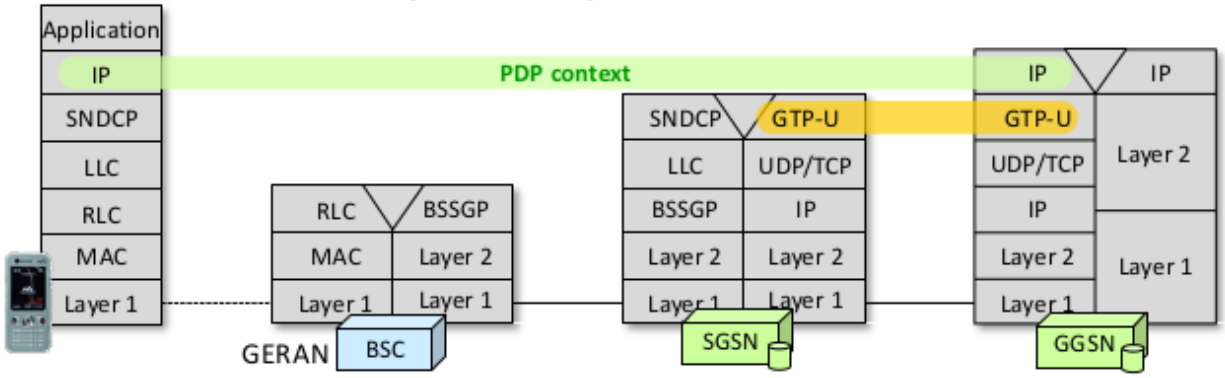
- Describes Characteristics of the Session
- Contains Routing Iformation form UE to GGSN
- A UE can have mutiple PDP Contexts
- Stored in UE SGSN GGSN
- Access point Name
- PDPType IPv4/6
- PDP Address Ip address of the UE
- QoS class -> latency throughput

Multiple PDP contexts

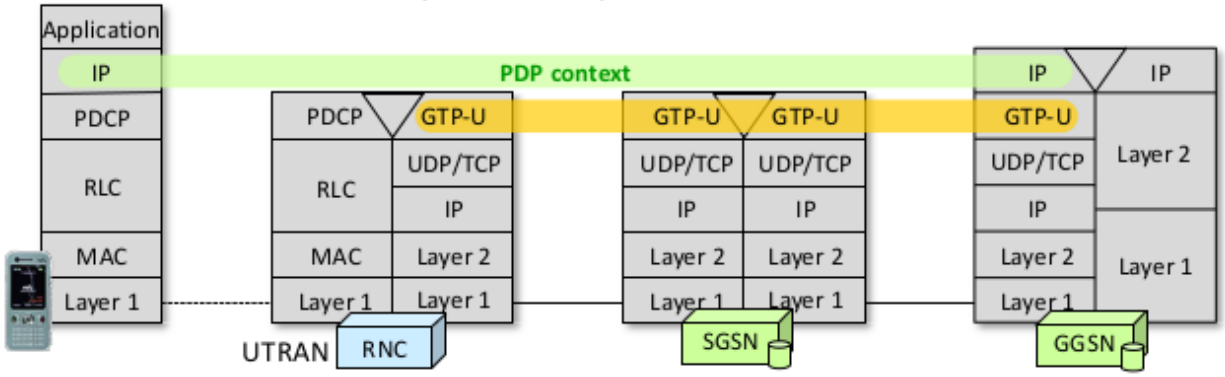
- UE with different PDP contexts
- Operators may use different PDP contexts with different APNs for charging different services in the Internet differently, for example
  - Mobile Web
  - Email
  - Tethering



GPRS Transmission Plane (User Plane)



UMTS Transmission Plane (User Plane)



Chapter 5: Mobile Web

WAP Architecture and Protocols

WAP 1.0

1997
benutzt WML/WML Script
Also Wireless Session/Transport/Transaction/Datagram Protocol
Bad User Experience

WAP 2.0

2000
main elements: XHTML-MP, HTTP-MP, TCP-MP

Fixed-Web

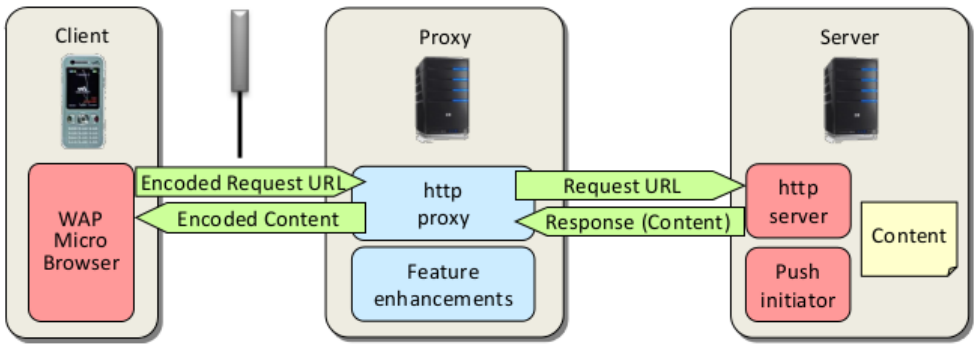
Design for fixed access only
Web Standard:

- Standard Naming Model (Uniform Resources Locators)
- Content Typing
- Standard Content Formats
- Standard Protocols
- HTML + TCP/IP

Mobile Web

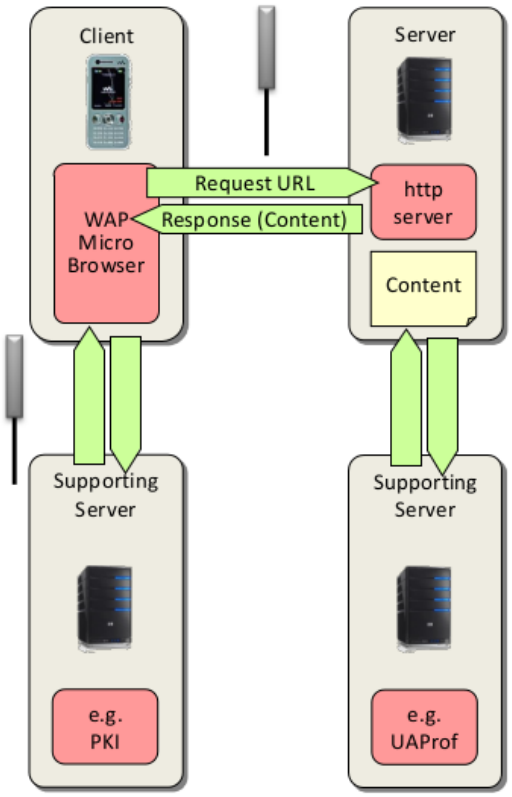
extensions for mobile enviroment

- PUSH available
- Wireless Telephony Application: telephone functions, e.g call control functioks
- Standard Naming Model URL+ URIs
- Standard Typing of the WWW
- PUSH and Pull Protocols



Proxies

- WAP utilizes proxy technology to optimize and enhance the connection between the wireless domain and the Web
- WAP proxy allows content and applications to be hosted on standard Web servers and to be developed using proven Web technologies
- *Protocol Gateway*: translates protocols from a wireless protocol stack (e.g., WAP 1.x) to the Web protocols
- *Content Encoders and Decoders*: translate WAP content into a compact format that allows for better utilization of the underlying link due to its reduced size
- *User Agent Profile Management*: describes capabilities of the respective mobile device and personal preferences
- *Caching proxy*: improves perceived performance and network utilization by maintaining a cache of frequently accessed resources

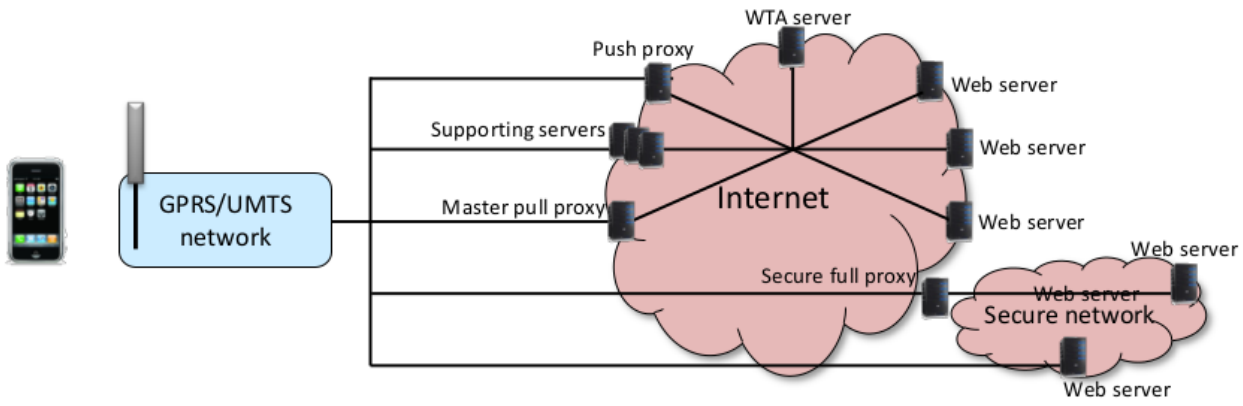


Supporting Services

- WAP Architecture includes supporting, which provide auxiliary functions to devices, proxies, and servers
- Supporting services are specific in function, but of general use to a wide variety of applications

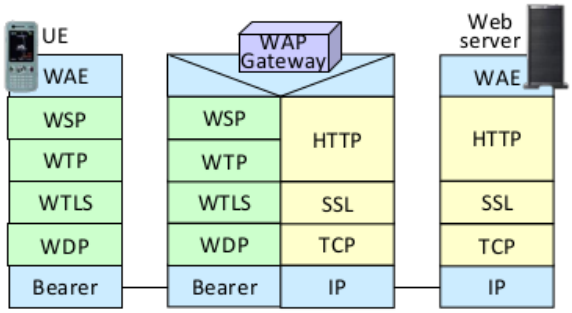
Examples

- *PKI Portal*: allows devices to initiate the creation of new public key certificates
- *UAProf Server*: allows applications to retrieve the UE capabilities and personal profiles of user agents and individual users
- *Provisioning Server*: supports the automatic configuration of devices, for example, w.r.t. network parameters, with minimal or no user interaction



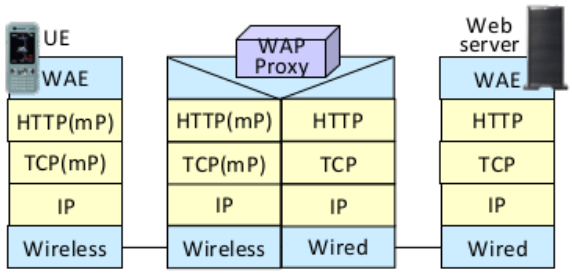
- WAP clients communicate with Web servers through a number of different proxies or directly
- WAP clients support a proxy selection mechanism for utilizing the most appropriate proxy for a given service or to connect directly to that service if necessary

- Proxies may be located in a number of places, including…
  - …mobile network operators in order to provide feature enhancements coupled to the mobile network (e.g., telephony, localization, and provisioning)
  - …independent service providers to optimize the communication between device and application server (e.g., protocol translation and cookie caching)
  - …secure network to provide a secure channel between UE and the secure network



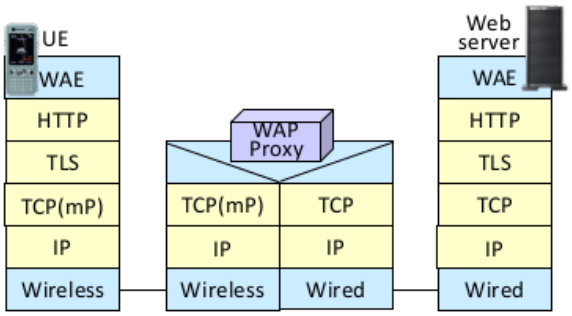
WAP 1.x Gateway

- Protocol stack of the original WAP architecture
- WAP Gateway converts between datagram-based protocol and connection-oriented protocols



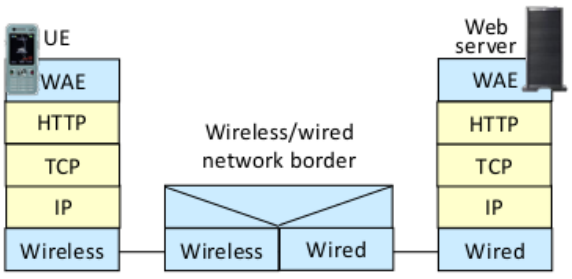
WAP HTTP Proxy with Profiled TCP/HTTP

- Widely used in the Internet for ordinary web access, multimedia data, etc.
- Like the WAP gateway, proxy is located between wireline and wireless networks to enhance performance by using the wireless profiles of TCP and HTTP
- Wireless profiled versions are interoperable with TCP and HTTP



WAP Proxy Support for TLS Tunneling

- Proxy is used for establishing a connection-oriented tunnel to the web server
- Allows TLS to provide end-to-end security between UE and origin server
- Widely used for enabling end-to-end security in E-Commerce scenarios



Direct Access

- UE directly accesses a Web server via the Internet
- Enables bearer level security (e.g., IPSec)
- Wireless optimizations as defined by the wireless profiles for TCP and HTTP are not available

From HTML to XHTML-MP

XHTML = intersection of html and XML, more resrictive subset of SGML, can be parsed by XML parser

XHTML-Basic = cutown version of XHTML for limted processing and displaying capabilities

XHMTL-MP = extended XHTML-Basic -> presentation and internal style sheets (WCSS WAP CSS)

Content Adaptation

Different CSS files for different Devices
Kleinstes gemeinsame
mutiple version of pages
Automatic Adaptation

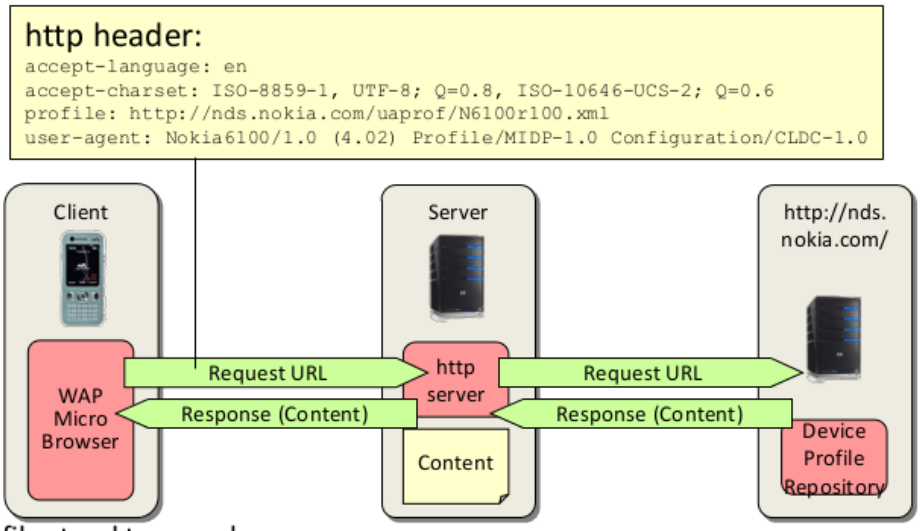
1. Start Encoding content with markup language all devices can manage
2. add basic styling
3. continue adding layers to make best possible user experience

User Identification what kind of devices via HTTP Header

CC/PP and UAProf

CC/PP stadnardized by W3C for publisching configuration details and capas to servers

User Agent Profile -> Concrete CC/PP Vocabulary



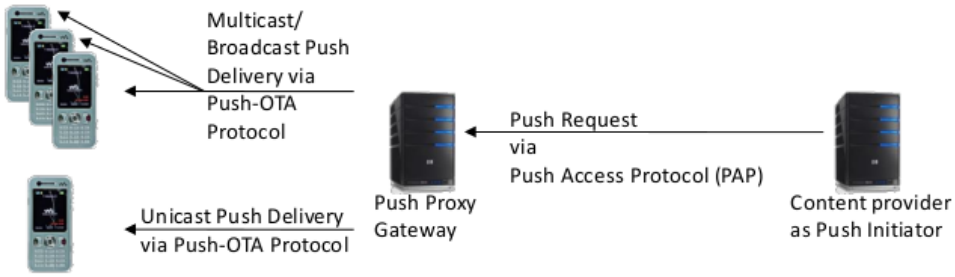
- UAProf files tend to grow large
- Common practice: only the URL of the device profile is transmitted from the mobile device to the content server
- Content server fetches the profile from a device profile repository and may store it in its own database for later use
- WAP gateways and HTTP proxies must support UAProf header forwarding

WURFL

XML configuration file which contains information and features of many mobile devices
Includes (and corrects) information from UAProf repositories maintained by the manufacturers

Push Service

No explicit request from the client before the server transmits its content



Push Proxy Gateway (PPG)

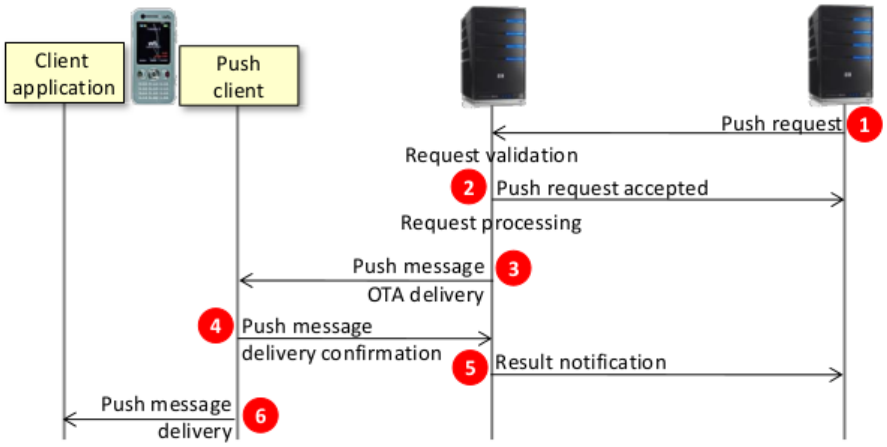
- Proxy for push operations initiated by external applications
- Gateway for converting external application and interface operations for delivery via Push Over-the-Air (OtA)
- Push client registration
- Push client address translation
- Push content transformation
- Store-and-forward support for push

Push Initiator (PI)

- Triggers the delivery of push content
- transmits the push content and delivery instructions to a PPG

Push Client

- Push software (daemon) at the mobile device permanently listening for incoming push messages
- Receives content and delivers it to the respective client application



1. PI sends a request for delivery of a new or replacement of a prior message
   - Indicates one or several target users and a client application to whom the message is delivered
   - PI may select various options for message delivery
2. PPG sends a confirmation or a reject
3. PPG delivers push message to the push client via Push-OTA protocol
4. Push client confirms delivery
5. PI is notified about the successful delivery of the push message
6. Push client passes the content to the client application (browser, multimedia messaging client, instant messaging client, email client,...)

PI to PPG is using HTTP POST
PPG to differnt kinds of options

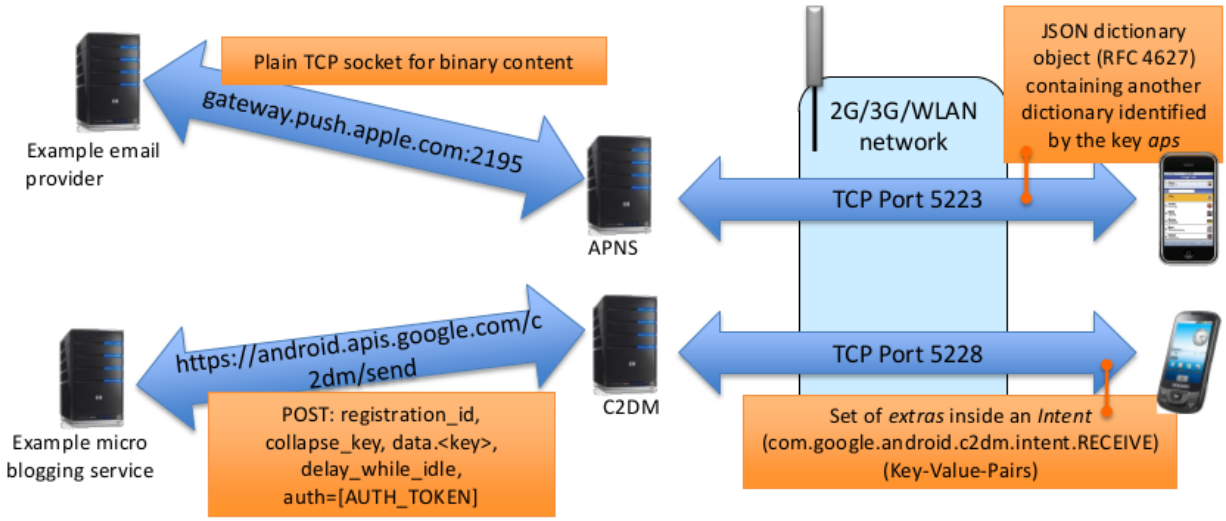
- Connectionless
  - local sms queuing
- Conection-oriented
- other
  - confirmed unconfirmed
  - can be set with expire date

How to notify an application that is running on a mobile device?

- Android: "Cloud to Device Messaging Framework (C2DM)"
- iOS: "Apple Push Notification Service (APNS)"

Basic idea:

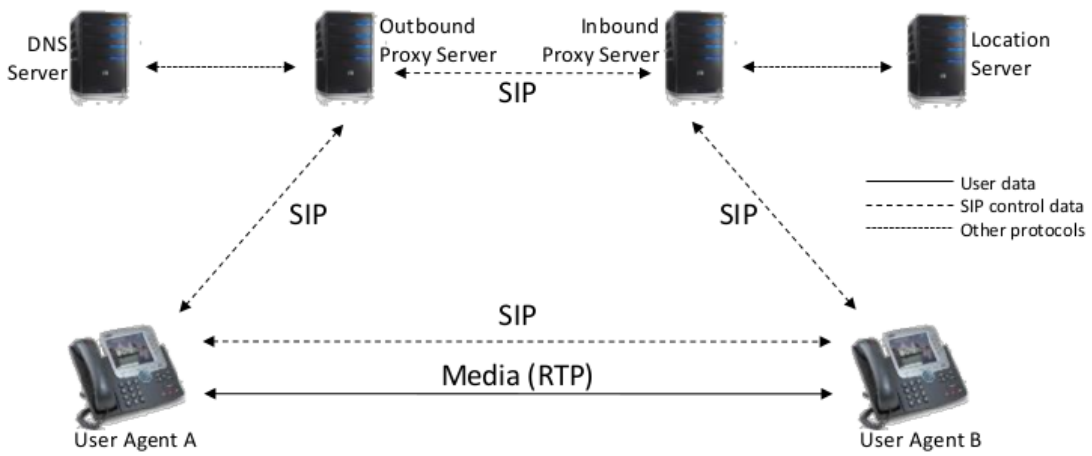
- Keep a single TCP connection between device and push proxy
- Multiple apps can receive notifications from multiple services via the proxy



Chapter 6 - SIP and IMS

Session Intiation Protocol

Application Layer Protocol
establishing, modifying, and terminating multimedia sessions
can be run over TCP or UDP



User Agent Client

- Caller application that initiates requests

User Agent Server

- Accepts, redirects, rejects requests and sends responses to incoming requests on behalf of the user

Proxy server

- Receives and forwards SIP requests
- Core component for mobility support

Registrar

- Used to store explicit binding between a user's address of record and the address of the device the user currently uses

Addresses

SIP URIs

- Follows the scheme
  sip:userinfo@host:port[parameters][headers]
- Examples for SIP URIs
  - sip:bob.smith@telekom.de
  - sip:bob@telekom.de; transport=tcp
  - sip:+1-121-555-1234@gw.com;user=phone
  - sip:root@136.16.20.100:8001
  - sip:bob@registrar.com;method=REGISTER

Tel URI

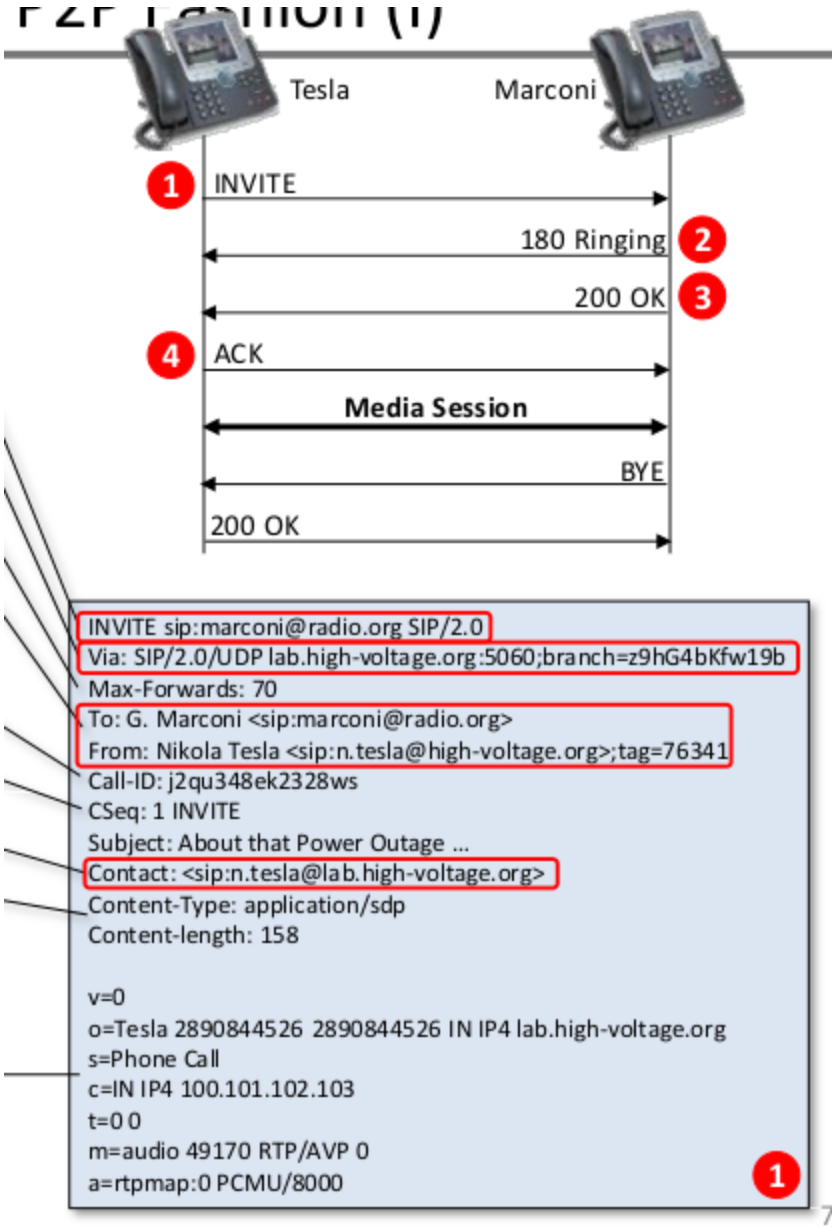
- Used to identify resources using a telephone number according to E.164
- Starts with a "+", while a local number follows the rules of local numbering plans
- Local numbers need to have a context-parameter, which makes it globally unique
- Examples:
  - tel:+358-9-123-45678
  - tel:45678;phone-context=example.com
  - tel:45678;phone-context=+358-9-123

Initial Set of URL Schemes

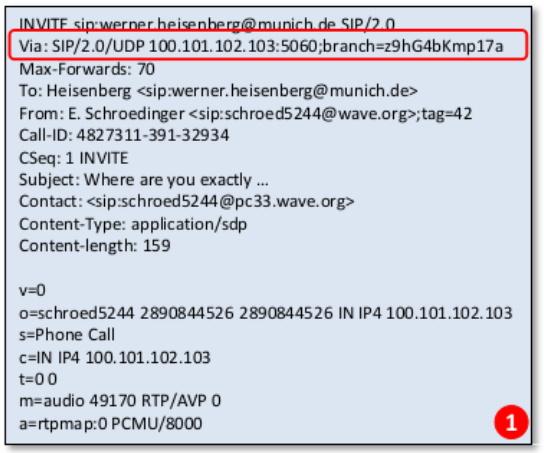
Scheme	Protocol
http	Hypertext Transfer Protocol
ftp	File Transfer Protocol
gopher	The Gopher Protocol
mailto	Electronic mail addresses
news	USENET news
nntp	USENET news using NNTP access
telnet	Remote login
wais	Wide Area Information Servers
file	Host-specific file name
prospero	Prospero Directory Service

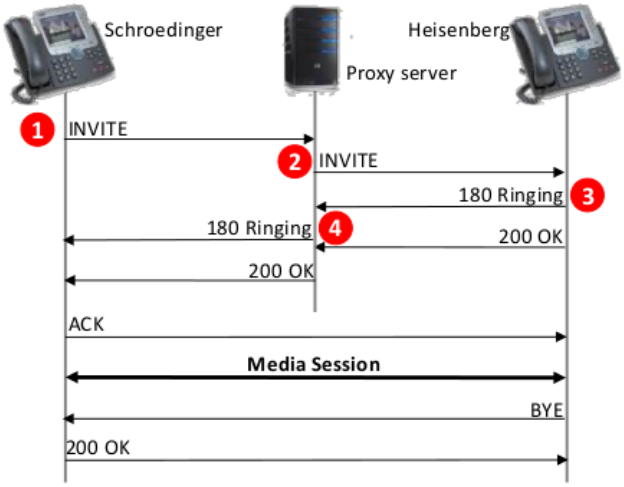
URL/URI Schemes used for SIP

Scheme	Protocol
sip	Session Initiation Protocol
sips	Secure SIP (TLS)
tel	Telephone number and dial string
im	Instant messaging inbox
pres	Presence
xmpp	Jabber IM and presence
h323	H.323


Tesla
Marconi
1
INVITE
180 Ringing
2
200 OK
3
4
ACK
Media Session
BYE
200 OK
INVITE sip:marconi@radio.org SIP/2.0
Via: SIP/2.0/UDP lab.high-voltage.org:5060;branch=z9hG4bKfw19b
Max-Forwards: 70
To: G. Marconi <sip:marconi@radio.org>
From: Nikola Tesla <sip:n.tesla@high-voltage.org>;tag=76341
Call-ID: j2qu348ek2328ws
CSeq: 1 INVITE
Subject: About that Power Outage ...
Contact: <sip:n.tesla@lab.high-voltage.org>
Content-Type: application/sdp
Content-length: 158
v=0
o=Tesla 2890844526 2890844526 IN IP4 lab.high-voltage.org
s=Phone Call
c=IN IP4 100.101.102.103
t=0 0
m=audio 49170 RTP/AVP 0
a=rtpmap:0 PCMU/8000
1
7

Mobility





- As Schroedinger does not know where Heisenberg is logged on and what device he is currently using, a SIP proxy server is used to route `INVITE`
- User Agent of Schroedinger performs DNS lookup of Heisenberg's SIP URI domain name (`munich.de`), which returns the IP address of the proxy server `proxy.munich.de`
- `INVITE` is then sent to the IP address of the proxy
- Proxy looks up the SIP URI `sip:werner.heisenberg@munich.de` in its database and locates Heisenberg
- `INVITE` is then forwarded to Heisenberg's IP address

11

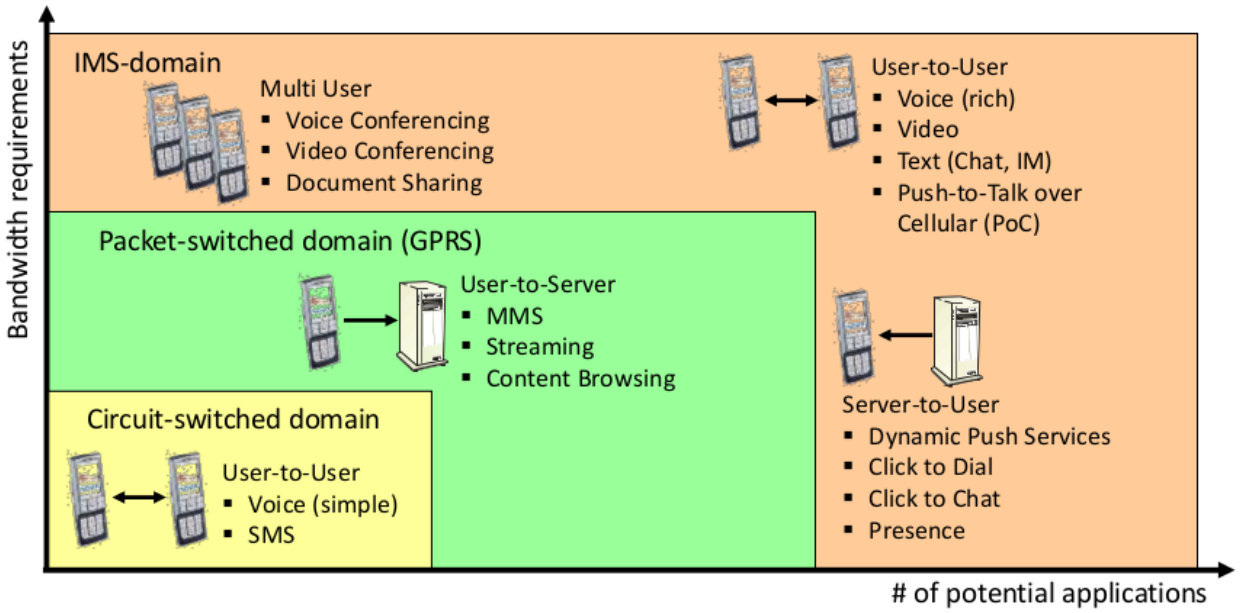
Register with a Reistrar (REGISTER message)

Personal Mobility (User on Other Device, register)
Terminal Mobility (Mobile IP, device in new Network)
Service Mobility (
Precall Mobility (always register to new and old proxy)
Midcall Mobility (**reinvite** when during session network was changed, **replaces** old session)

IP Multimedia Subsystem

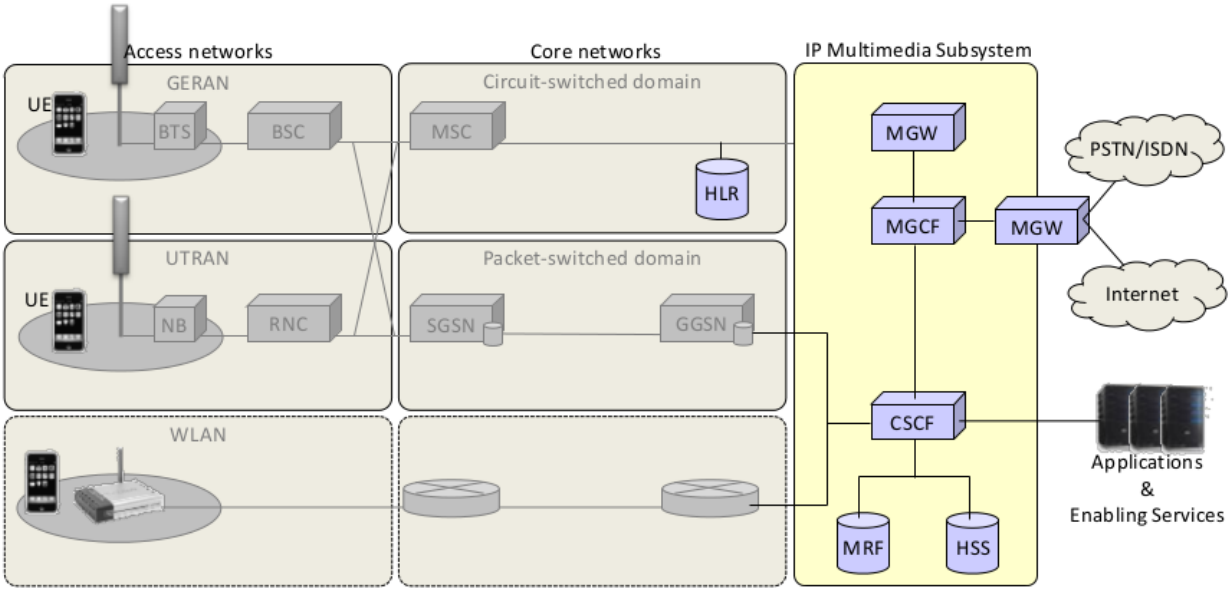
Uses SIP for session Control

- **Mutiple Services – Single Session** (change media type inside a session)
- **Synchronized Services – Mutliple Session** (interlinked services, trigger other services with new sessions
- **Unrelated Service – Mutiple Sessions** (unrelated services running in parallel, independet Sessions)



- IMS provides Quality-of-Service (QoS) mechanisms
- QoS parameters like transmission rate, gateway delay and error rates can be measured, improved and guaranteed in advance
- Users are able to specify the level of quality they require depending on the type of service
- Terminal, network, and service mobility
- Rich set of charging functions, including …

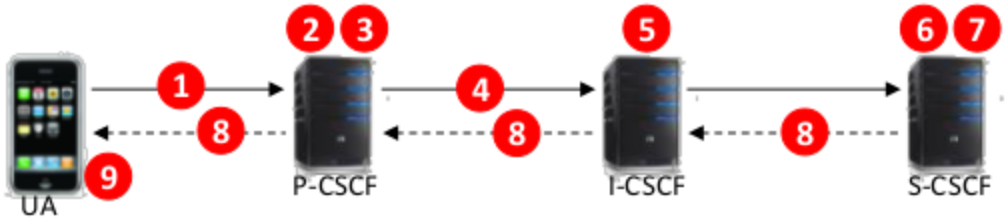
Architecture



Call Session Control Function (CSCF)

- CSCFs are SIP Proxies

- does not route
- different versions
  - P-CSCF (Proxy)
  - I-CSCF (Interrogating)
  - S-CSCF (Serving)

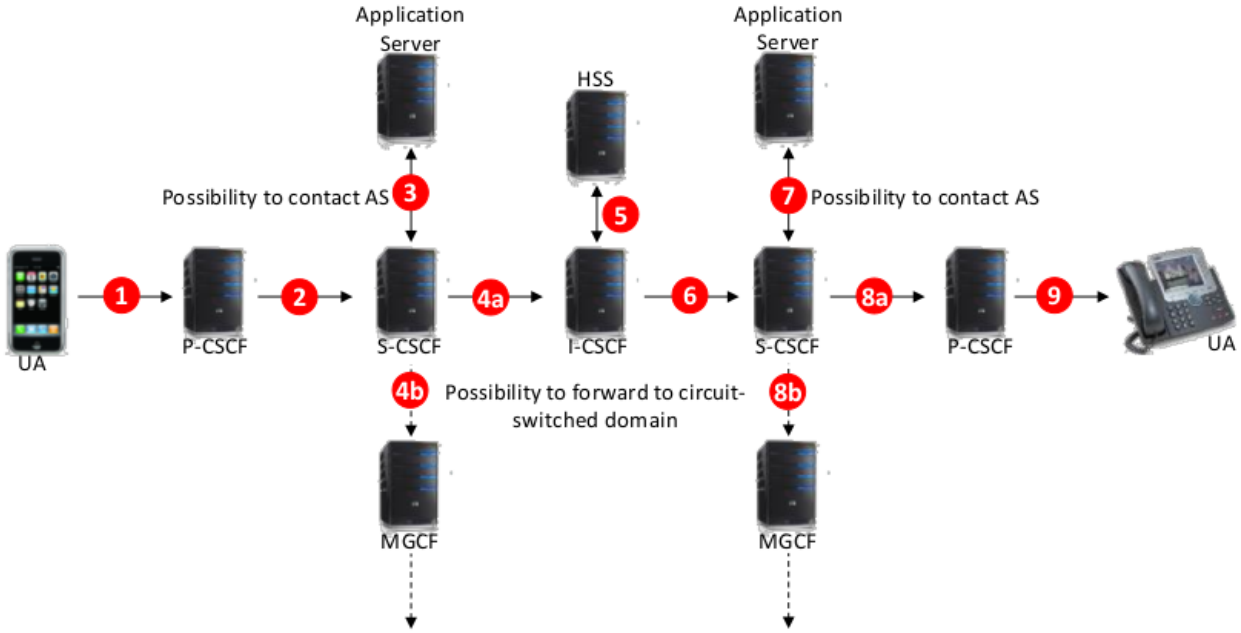


1. Send REGISTER (SIP URI <-> IP address)
2. Routes via P-CSCF/Outbound Proxy
3. Queries DNS for I-CSCF address
4. Puts own entry into Path header
5. Selects S-CSCF
6. Binds Contact URI to user's SIP URI
7. Store path header
8. Sends Service Route in 200 OK
9. Store service route

Home Subscriber Server (HSS)
- Combination of HLR und AuC
- Data Storage for subscriber and service related data

Media Resource Function (MRF)
- Playing Announcements
- Text2speech conversations

Media Gateway Function and MGW Control Function
- Interconnects circuit switche channels and media streams from packet networks
- Media Conversion
- Bearer Control
- Payload Processing



Chapter 7 - Mobile Operating Systems

Chapter 8 - Location-Based Services and Positioning

LBS Overview and Classification

Reactive LBSs

Explicitly invoked by the user
User or another person is located only during the service session

Procative LBSs

Automatically initialized as soon as a predefined location event occurs

Self-directional LBSs

User and target are the **same individual**
User's location is processed for his own purposes

Unidirectional LBSs

roles of user and target are adopted by **different individuals**

Bidirectional LBSs

Mutual exchange of location data between different participants

Outdoor LBSs

Cover large geographical areas and make use of satellite or cellular positioning technologies

Indoor LBSs
Positioning is based on proximity sensing or fingerprinting and position fixes have typical accuracies in the range of some meters or even centimeters

Network Centric LBSs
Positioning process is managed and coordinated by the control plane of the serving network

Terminal Centric LBSs
Positioning is entirely decoupled from the infrastructure of the serving mobile network operator

Client/Server versus P2P Operation

Fundamentals of Positioning

Positioning/Features/Observables (angles, ranges, range differences, velocity)

Quality Parameters
1. Accurarcy
2. Precision
3. Yield and Consistency
4. Overhead
5. Latency
6. Roll-Out-Costs
7. Operating Costs

Global Positioning System
20k km GPS
36k km geostationär

GPS Control Segment
Monitor Stations
Uplink Stations
Master Control Stations

GPS Satelite Constellations
Every Point on Earth coverd by 4 Satelites
But more in space to replace malfunctioning ones

Pilot Signals and Spreading Codes
GPS Positioning: terminal-based - circular lateration - timing measurements by code phase ranging

GPS pilot signals

- Carry two different ranging codes that are used for measuring the signal traveling time
- Carry a navigation message, which contains assistance data like satellite orbits, clock corrections, and system parameters

C/A Code
moderate level of accuracy
Used for civil purposes
P-Code
much better accuracy than C/A codes
Can only be interpreted by military applications

Navigation Message

Navigation message is transmitted in a frame structure

25.04.14

- Infrastructure vs Ad-hoc Networks

- FDM frequency Division Multiplex und CDM Code Division Multiplex in GSM

GPRS:

- multiple Device types A (Telefon and GPRS Same time), B (one at a time) and C (just GPRS)

- GPRS ciphering between UE and SGSN. More Secure than GSM and Allowes faster Hand Overs.

- GPRS Network uses IP

- only the Routing table of the GGSN is Dynamic

UMTS:

- New Access Network but GPRS Core Network.

- new frequency, New Antennas

- Voice and Data Traffic should go the Same Way

- 5MHz

GSM and UMTS Handover is possible

13.05.14 - UMTS ausbaustufen und LTE

- Splitting one Bit into Several Bits
Ex. 1 Bit to 1111
Chip rate of 4
UMTS Constant Chip rate of 3,84 mbps
- higher Spreading factor Allowes More Users
- next step different Spreading Factors for different Users. Allowes different connections Speeds ex Video Conference/Browsing Websites
- orthogonal variable Spreading Factors
- Codes have to be orthogonal in a tree of Codes

- cell breathing, reception Cells get bigger if leas Users and smaller with more Users connected.
- preventing cell Edge Users to drop with higher Spreading Factors-> less errors

23.05.14 - Handover Management

- mobile Station Updates its Location if it leaves a Location area to the next one
GSM Hybrid Location update
1. time Based
2. Forming LAs

17.06.14 - SIP und IMS

-

20.06.14 - IMS

- requires ip
- universal for Edge GPRS GSM whatever
- sip -> session initiation protocol - find sip address for current ip address

- uses Services enablers

24.06.14

8.1 Mobile Operating Systems

- iOS
- Android

- Symbian (Nokia)
- Windows Phone

8.2 Mobile Ecosystems

- Marketplaces
- Magazine Subscription

8.4 Android Overview

- Activity Lifecycle