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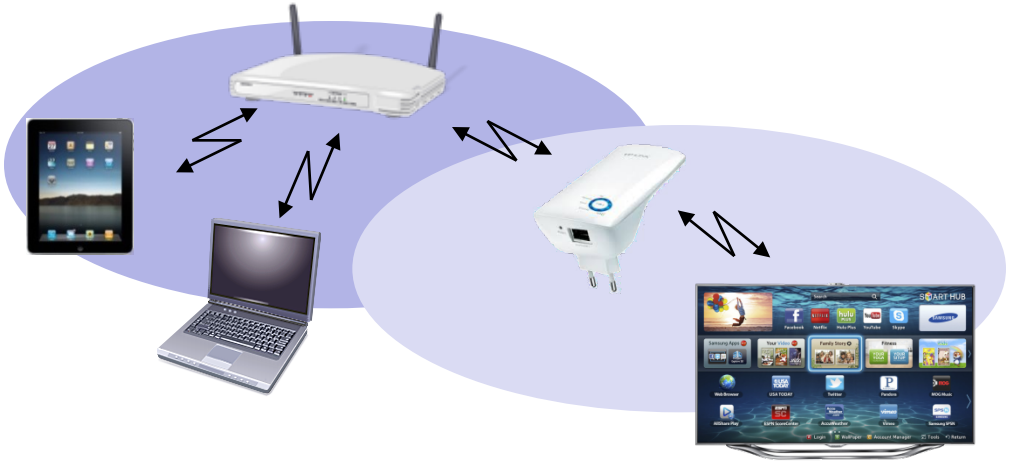
Lecture 3

Wireless Internet-oriented Infrastructures and Protocols



Mobile Business I (WS 2015/16)

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Overview

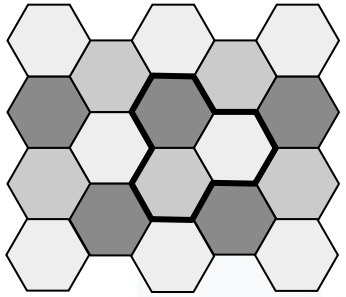
- Wireless LAN
  - Basics
  - Components and Infrastructures
  - State-of-the art Encryption
  - Mobility and Roaming
- Mobile IP – Mobility support for TCP/IP
- IP-based Radio Access Networks

Wireless LAN Basics
General

- Wireless communication based on radio as transport medium
- Cell based architecture
- Extension to a (wire based) LAN
- One cell serves an area in which PCs, laptops, and other connected devices can move freely.
- The term "Wi-Fi“ is
  - used in general English as synonym for a Wireless Local Area Network (WLAN),
  - a trademark owned by the *Wi-Fi Alliance*, a trade association promoting Wi-Fi technology.

Wireless LAN Basics
Radio Cell

- The basic module of a Wireless LAN is a so-called radio cell.
- A radio cell covers a circular area that PCs or laptops and other connected devices are able to use.



- A WLAN radio cell can be an add-on for already existing cable-based networks.

Wireless LAN Basics
Beacon Frame

- The Access Point is transferring a periodical beacon. A beacon communicates the Service Set Identifier (SSID) and other important operational parameters (channel, …)
- A Wireless LAN client sends a probe request. The Access Point answers with a probe response. If there is an agreement, the Wireless LAN client starts the communication over the Access Point.
- A more detailed description of beacon frames can be found in [Sauter2008].

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Wireless LAN Basics
802.11 Standard

Standard	Description
802.11	Protocol for transmission methods for wireless networks, defined in 1997 for 2 MBit/s at 2,4 GHz
802.11a	Wireless LAN **up to 54 MBit/s** at 5 GHz
802.11b	Wireless LAN **up to 11 MBit/s** at 2,4 GHz
802.11f	Roaming between access points of different manufacturers (published in 2003 and withdrawn by IEEE in 2006) [IEEE2010]
802.11g	Wireless LAN **up to 54 MBit/s** at 2,4 GHz
802.11i	Extended security features: AES, 802.1x, TKIP
802.11n	Wireless LAN **up to 450 MBit/s** when using 3 spatial streams (3x 150 Mbit/s) at 2,4 GHz or 5 GHz *)
802.11r	Fast Roaming/Fast BSS Transition
802.11ac	Wireless LAN using 3 spatial streams at 5 GHz: **Up to 1.3 GBit/s** (3x 433 Mbit/s) or even **up to 2.6 GBit/s** (3x 867 Mbit/s, part of *802.11ac Wave2*) *) **)
802.11ad	Wireless LAN at 60GHz: **Up to 7GBit/s**

*) 802.11n and 802.11ac data rates depend on the number of antennas and spatial streams ("parallele räumliche Inhaltsströme") supported by the hardware. 802.11ac devices often support 3 streams at most. 802.11n specifies a maximum of 4 streams, 802.11ac a maximum of 8 streams.

**) 802.11ac is a 5 GHz-only standard, so dual-band access points and clients will probably continue to use 802.11n at 2.4 GHz in parallel.

[IEEE] [Sauter 2008]

Wireless LAN Basics
Bandwidth Volatility

- Wireless LAN bandwidth depends on the **chosen standard**, the **distance** between client and access point, and the construction and quantity of **walls**.

Bandwidth 802.11b	Outside	Inside (Office)	Inside (House)
11 Mbps	~ 160 m	~ 50 m	< 20 m or max. 1 wall
5.5 Mbps	~ 270 m	~ 70 m	< 30 m or max. 2 walls
2 Mbps	~ 400 m	~ 90 m	< 40 m or max. 3 walls
1 Mbps	~ 550 m	~ 115 m	< 50 m or max. 4 walls

[Lanz 2003]

- **802.11b** uses the **2.4 GHz frequency band**. Reach depends even more on local circumstances when using newer IEEE standards together with **5 GHz frequency band**.

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Wireless LAN Components

- Components (802.11b)
  - Access Point (AP)

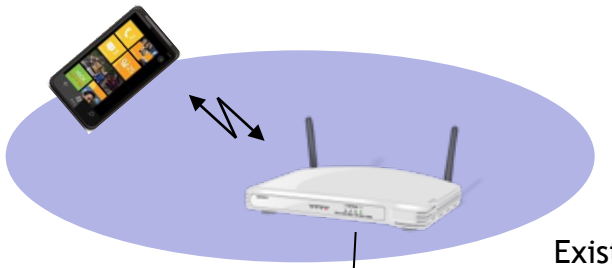
    Sender and receiver station that allows the connecting of many stations

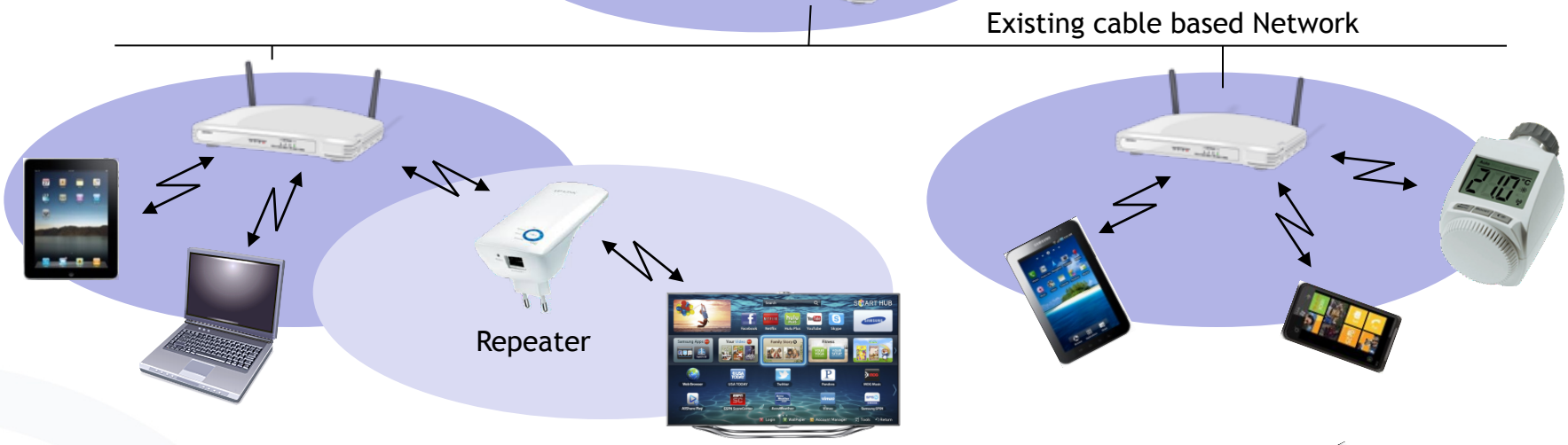
  - Stations

    End-systems that establish a wireless connection e.g. by using an Access Point (e.g. a notebook with built-in Wireless LAN)

Wireless LAN Infrastructures

Infrastructure Network





Ad hoc Networks

Based on [Sauter 2008]

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Wireless LAN
State-of-the art Encryption

- There are numerous methods for Wireless LAN encryption.
- We are only looking at methods that use a pre-shared key (PSK).
- WEP encryption methods are outdated and hence insecure:
  - Wired Equivalent Privacy (WEP) 64-bit
  - Wired Equivalent Privacy (WEP) 128-bit
- WEP 128-bit can be by-passed within minutes. [Heise 2007]

Wireless LAN
State-of-the art Encryption

- **Wi-Fi Protected Access (WPA)** was developed by the Wi-Fi Alliance. [Wi-Fi 2010]

- There are two versions of **Wi-Fi Protected Access,** WPA and WPA2:
  - **WPA** includes most of the 802.11i standard, but is **outdated and insecure** as it has various weaknesses:
    - Vulnerability to dictionary attacks when using a weak PSK
    - Other weaknesses inherited from earlier standards [ArsT 2008]
  - **WPA2** includes **802.11i** to its full extent and also the Advanced Encryption Standard (AES).

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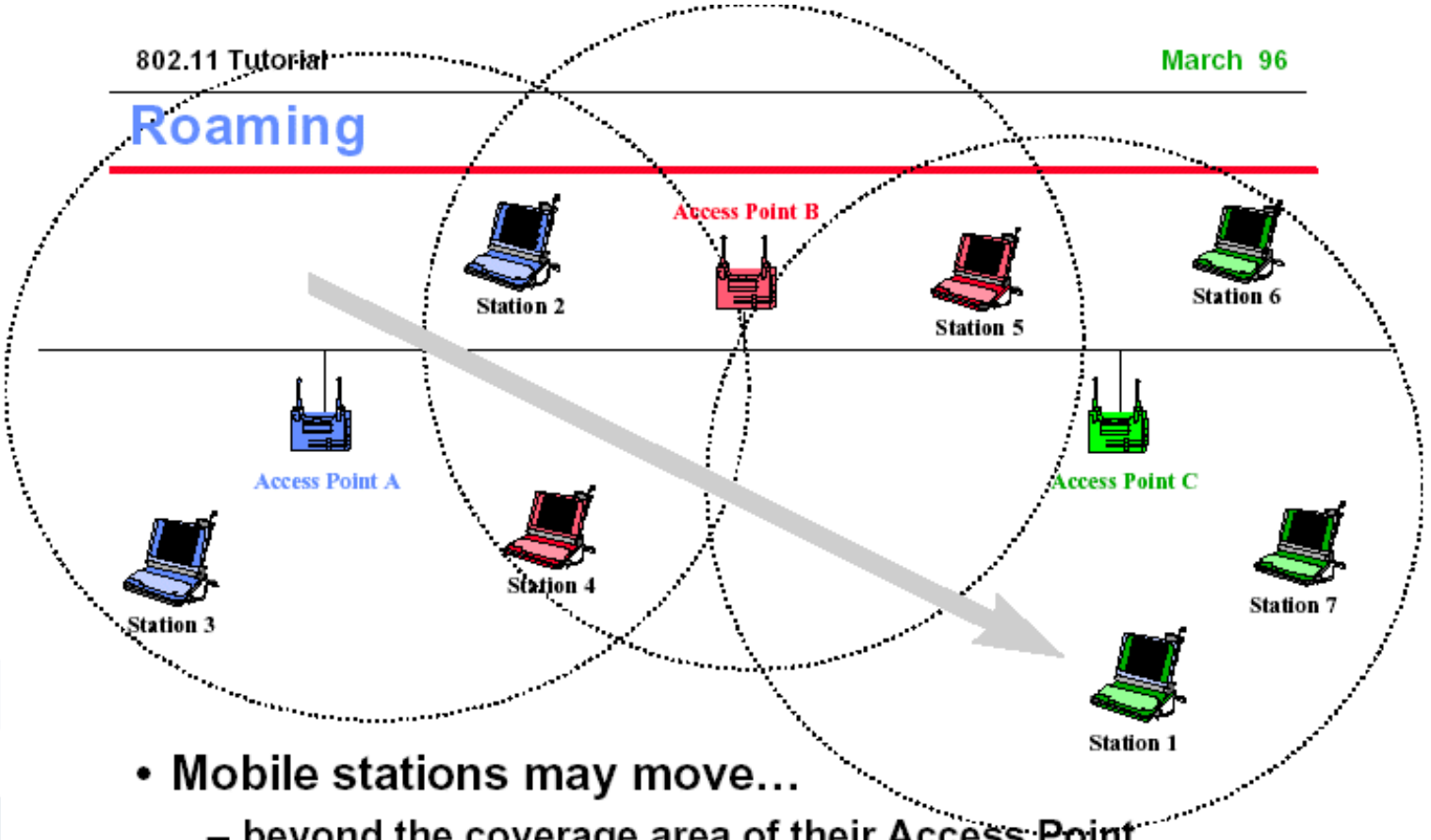
Restrictions of WLAN Mobility

- No existing standard for “handover” or “roaming” between:
  - Access points (AP)
  - Different providers of APs
- Change of AP leads to
  - Connection interrupt
  - New connection/authentication
- Non-uniform accounting / user administration

→ Some of the reasons why WLAN will not replace mobile communication networks

Wireless LAN Mobility Problems



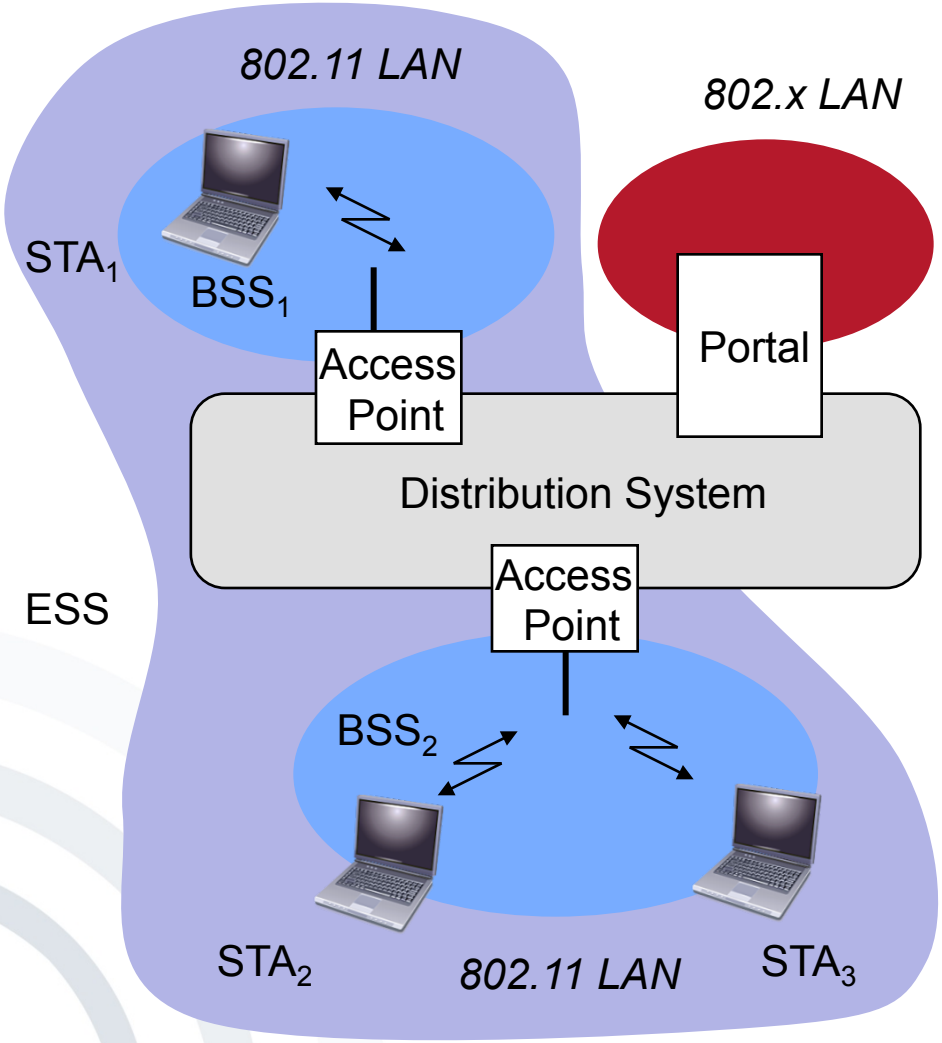
- Mobile stations may move…
  - beyond the coverage area of their Access Point
  - but within range of another Access Point
- Reassociation allows station to continue operation

[IEEE 1996]

Wireless LAN “Roaming”

- Approaches to perform “roaming”
  - By a combination of several access points a so-called distribution system is growing.
  - Every access point covers one radio cell.
  - Upon leaving a radio cell the station starts scanning for other existing access points (which may use the same SSID, but a different transmission channel) and tries to connect.
  - Following the connection to a new access point the distribution system and the access point that was used before will be informed.

Wireless LAN “Roaming”



Station (STA)

- Computer with access to the wireless medium and radio connect to the AP

Basic Service Set (BSS)

- Group of stations, which use the same radio frequency

Access Point

- Station which is integrated into the radio as well as the fixed local area network (distribution system)

Portal

- Transfer into another network

Distribution systems

- Connection of different cells for building a larger network (ESS: Extended Service Set)

Wireless LAN Mobility
Fast BSS Transition (802.11r)

- **BSS = Basic Service Set.**
  A *Basic Service Set (BSS)* is one Wireless LAN access point + all associated stations.
- The client decides which access point to (re)connect to in case the connection to the previous access point is lost (e.g. due to the client moving out of range).
- Wireless security protocols induce interruptions of several seconds during necessary reconnection (problem when using Voice-over-IP telephony connections!).
- Since 2008 a standard for "roaming" between Wireless LAN access points is available:
  IEEE 802.11r = fast roaming and fast BSS transition
  - As of February 2013, no Intel devices support the 802.11r standard. [Intel 2013]
  - For Apple devices iOS 6 introduced support for 802.11r (optimized client roaming on enterprise Wi-Fi networks). [Apple 2012]

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Mobile IP
Mobility with TCP/IP

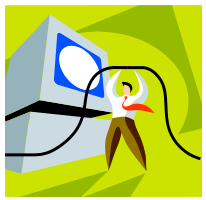
The situation today:

- Separate IP addresses in the office and at home
- DHCP – dynamic IP address assignment
- Dial-up with dynamic IP addresses
  - Continuous accessibility via one IP address is not guaranteed.
  - Connection interruptions during access point switches

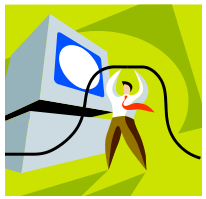
Mobile IP
Routing in TCP/IP

- Routing takes place from Partner A node to Partner B node and in reverse direction.
- Both nodes have their own address.
- The route follows the addresses.
- Routing of data packets by routers

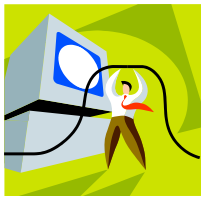
Partner B
IP address, e.g.
61.9.193.200



Router



Router



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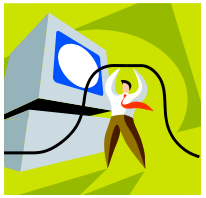


Router

Partner A
IP address,
e.g. 141.2.74.211

Mobile IP
Addressing of Mobile Devices

Standards

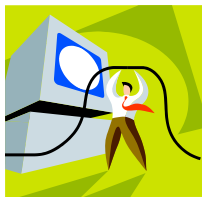
- Internet Engineering Task Force (IETF)
  www.ietf.org
- RFC 2002: IP Mobility Support
- RFC 2977: Mobile IP Authentication, Authorization, and Accounting Requirements

Mobile IP
Mobility problem

Partner B changes network

Old IP address (Partner B)

New IP address (Partner B)



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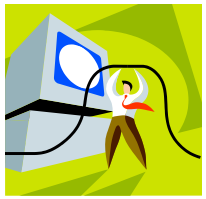

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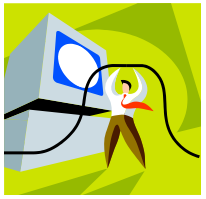
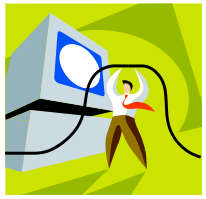


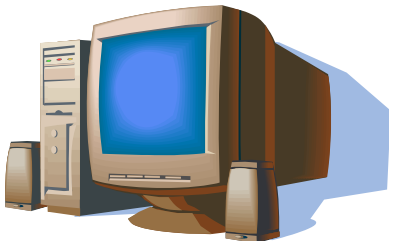
Router



Router

Partner A

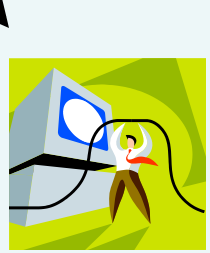
Mobile IP
Mobility solution - Layer 3



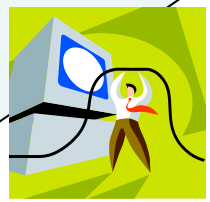
Redirection (“Tunneling“) via home address to mobile device

Home address (Partner B)

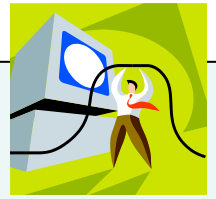
New IP address (Partner B)



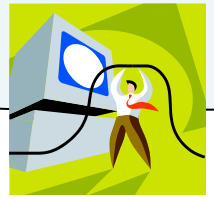
Router



Router



Router



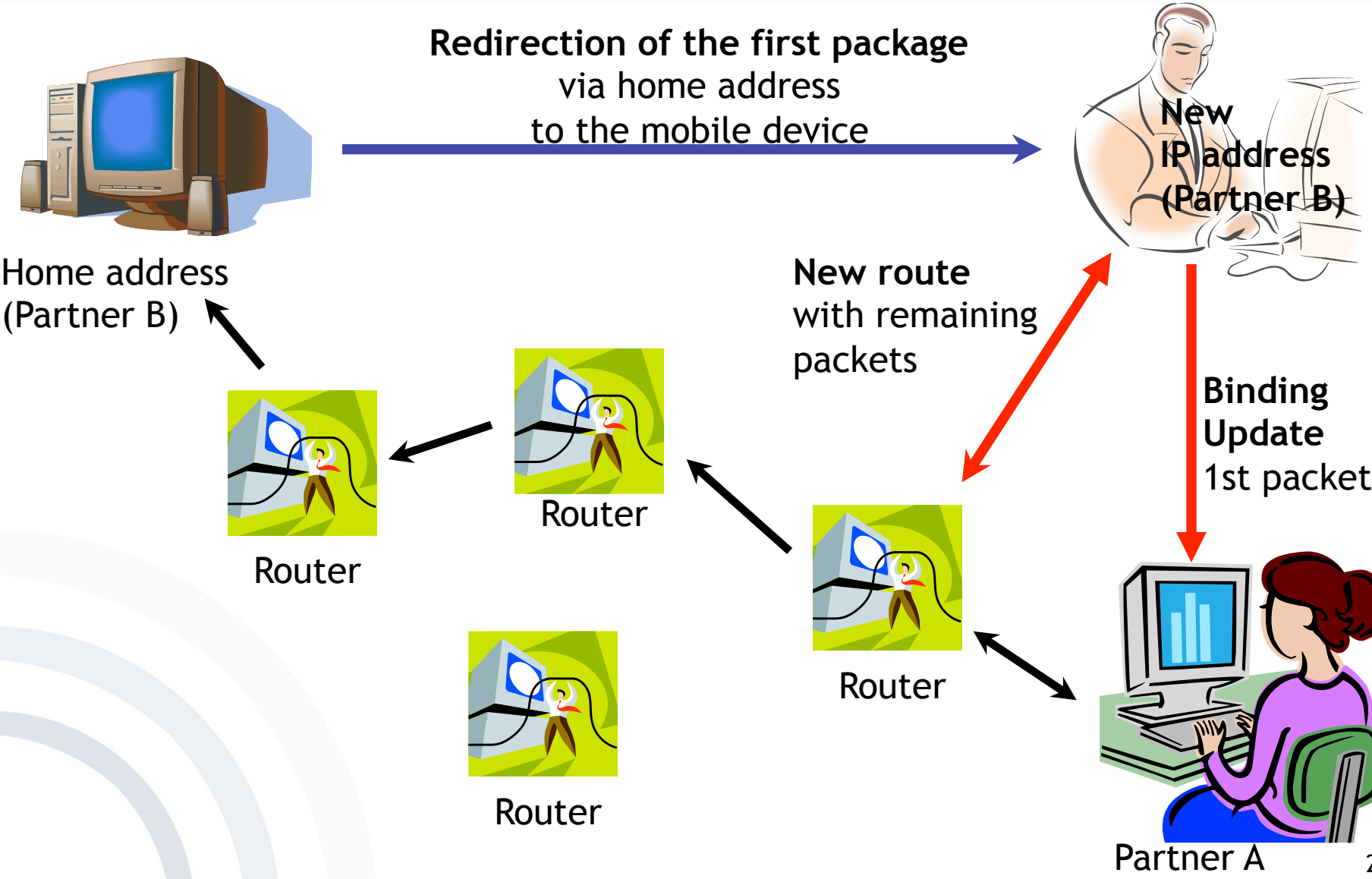
Router

Partner A

Mobile IP
Mobility solution - Layer 3

- **But** redirection implies
  - A longer route than before
  - Higher runtime
  - Avoidable usage of resources

Mobile IP
Mobility solution - Binding Update



Security for Mobile IP

- Possible attack with illegitimate binding update: **Capture the route** and redirect the TCP/IP session.

  ➲ **Therefore, authentication** of Binding Update (BU) messages and address check is required.

- In addition, **observation** of user movements through their Binding Updates!

  ➲ Anonymous communication-channels are necessary to protect privacy.

Domain Names and Mobile IP

- In the **Domain Name System** a domain-name belongs to a fixed IP address (e.g. www.m-lehrstuhl.de = 141.2.66.180).
  - **Changing** these addresses requires an update-time of several hours ➲ this is no usable solution.
- **Better solution: Dynamic DNS**
  - Modification time: 15 minutes
  - Problem: applications resolve a name just once and do not query possible address changes thereafter.

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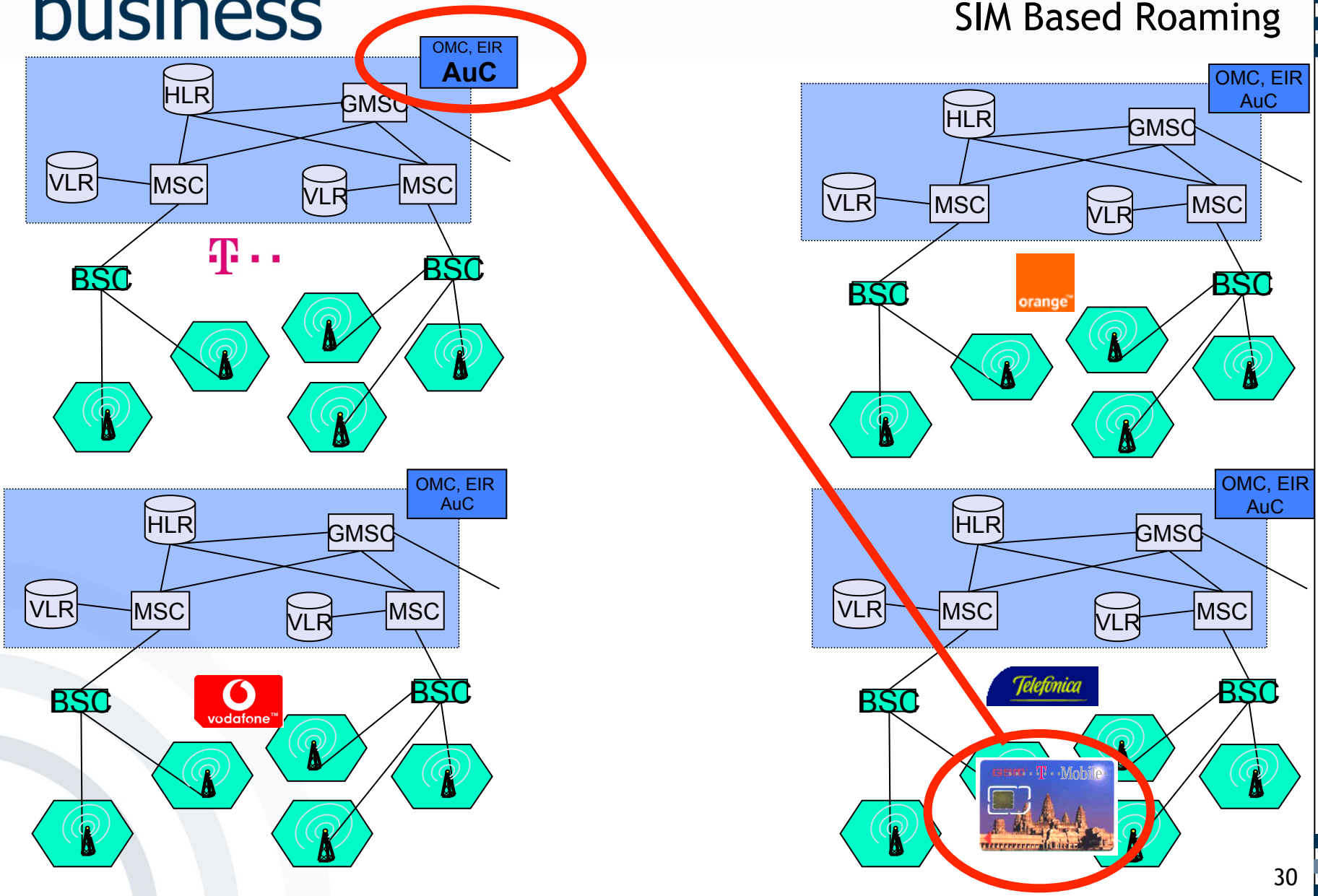
Roaming

SIM Based Roaming



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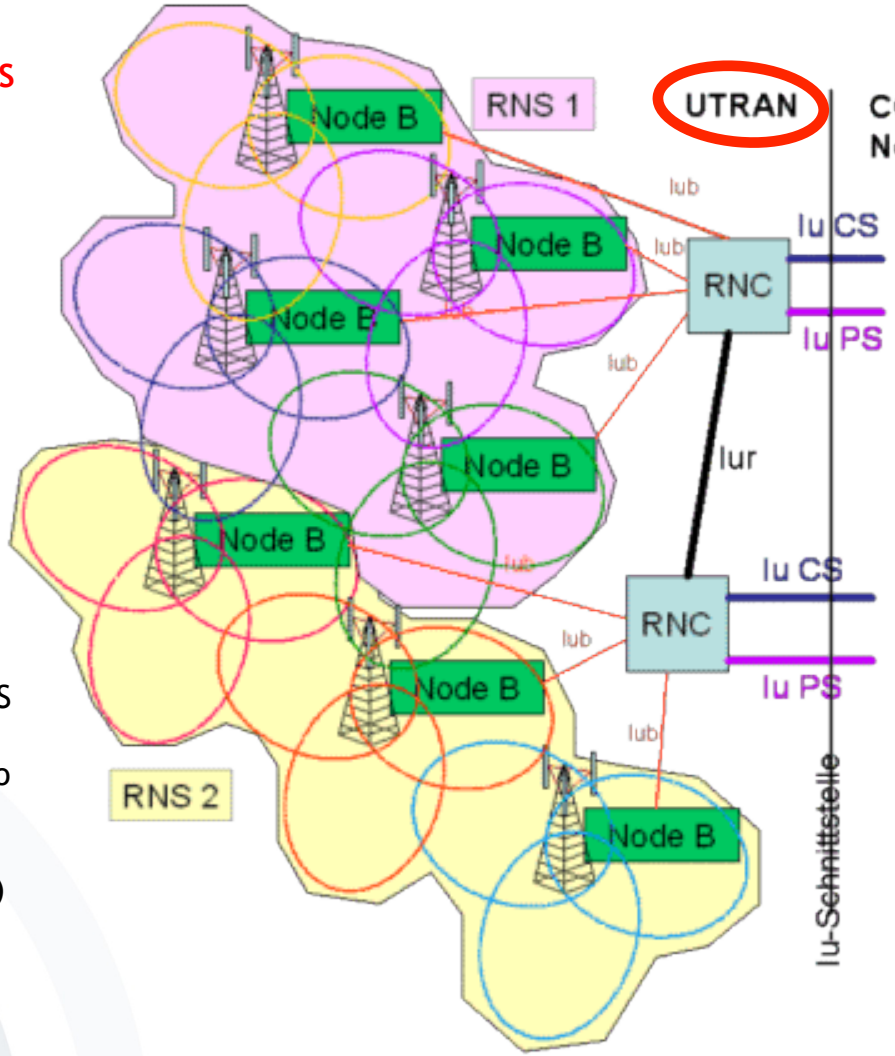
UMTS (3G) System Architecture

- ***UTRAN:*** **UMTS Terrestrial Radio Access Network**
- ***RNS:*** Radio Network Subsystem
- ***RNC:*** Radio Network Controller (controls the Node Bs)
- ***Node B:*** UMTS base stations (equivalent to base transceiver stations (BTS) in GSM



UMTS Core network
- is not shown here in detail
- UMTS Core network corresponds to Network- & Switching Subsystem (NSS) in GSM

Source: UMTSlink.at (2011)

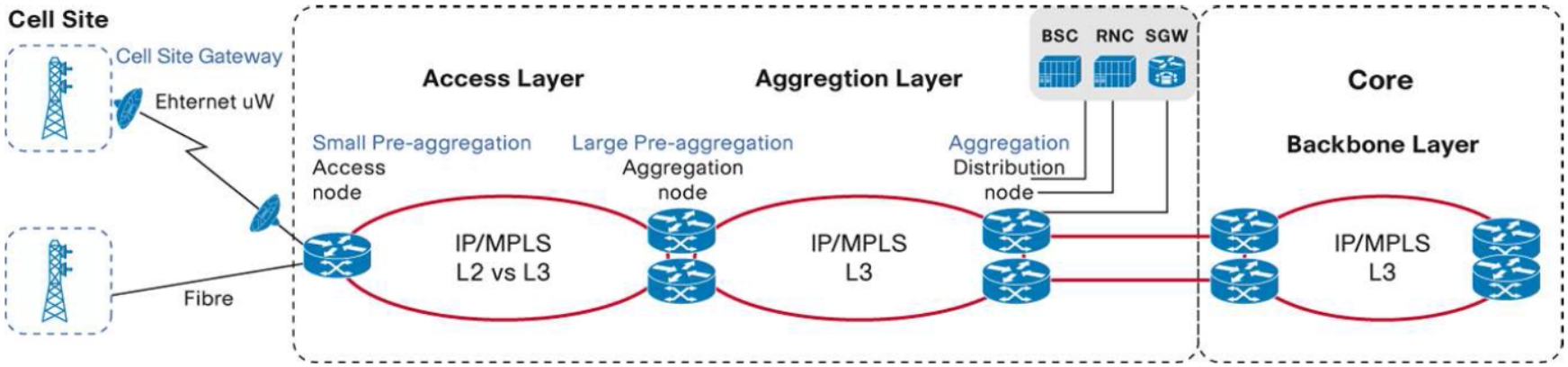
Radio Access Networks (RAN)

- Part of a mobile telecommunication system
- Provides connection between device (phone, computer, or machine) and core network
- Implements certain radio access technologies, e.g. GSM or 3G
- Examples of radio access network types are:
  - **GRAN:** GSM radio access network
  - **GERAN:** essentially the same as GRAN but specifying the inclusion of EDGE packet radio services
  - **UTRAN:** UMTS radio access network
  - **E-UTRAN:** Long Term Evolution (LTE) high speed, low latency radio access network
- Some handsets have capability to be simultaneously connected to multiple RANs (dual-mode handsets).

[Wiki 2014]

IP-based Radio Access Networks (IP RAN)

- All different backhaul technologies may be collapsed onto a single IP/MPLS network (MPLS = Multiprotocol Label Switching) → End-to-end IP approach
- Support for legacy services and reduced cost per bit
- 2G, 3G, and 4G radio technologies transparently supported
- Cost savings possible due to alternative transport media (such as Ethernet and DSL)



[Cisco 2011] [Cisco 2014]

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