Διαχείριση Edge και Cloud δικτύων βασισμένων στο λογισμικό (CSIS109)

Δρ. Ειρήνη Λιώτου

eliotou@hua.gr

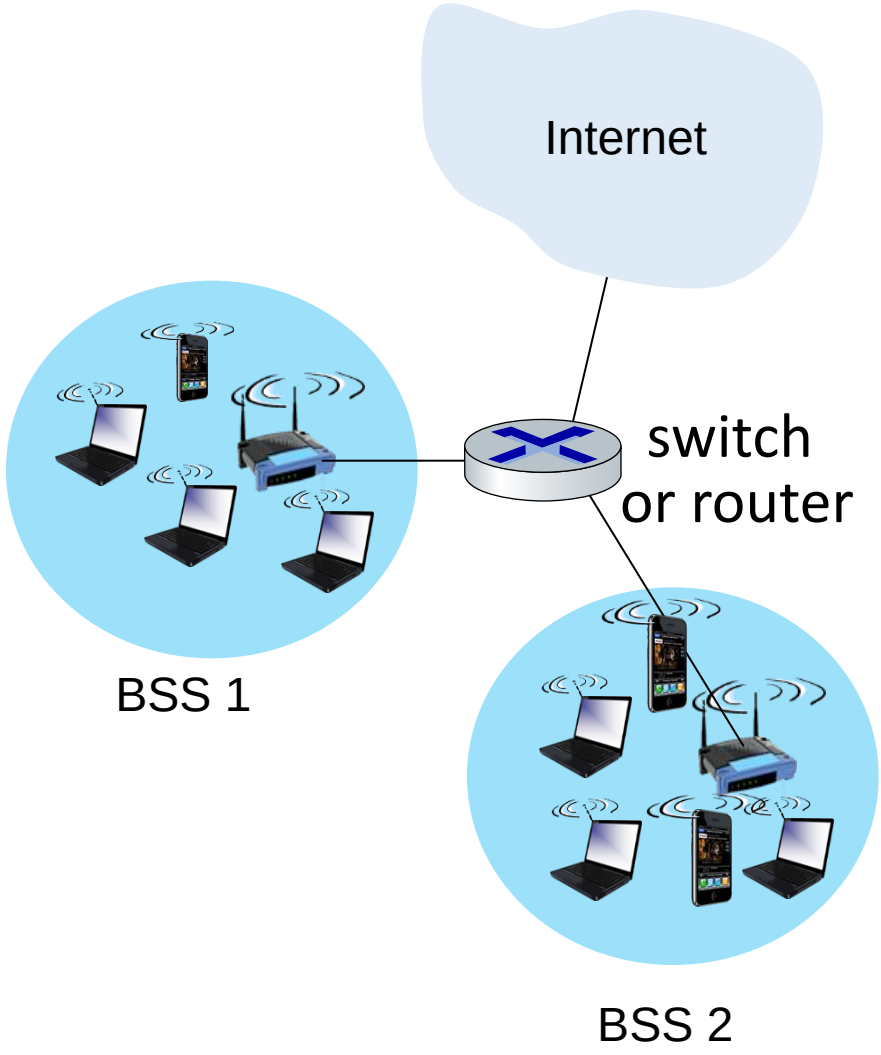
8/4/2025

IEEE 802.11 Wireless LAN

IEEE 802.11 standard	Year	Max data rate	Range	Frequency
802.11b	1999	11 Mbps	30 m	2.4 Ghz
802.11g	2003	54 Mbps	30m	2.4 Ghz
802.11n (WiFi 4)	2009	600	70m	2.4, 5 Ghz
802.11ac (WiFi 5)	2013	3.47Gpbs	70m	5 Ghz
802.11ax (WiFi 6)	2020 (exp.)	14 Gbps	70m	2.4, 5 Ghz
802.11af	2014	35 – 560 Mbps	1 Km	unused TV bands (54-790 MHz)
802.11ah	2017	347Mbps	1 Km	900 Mhz

- all use CSMA/CA for multiple access, and have base-station and ad-hoc network versions

802.11 LAN architecture

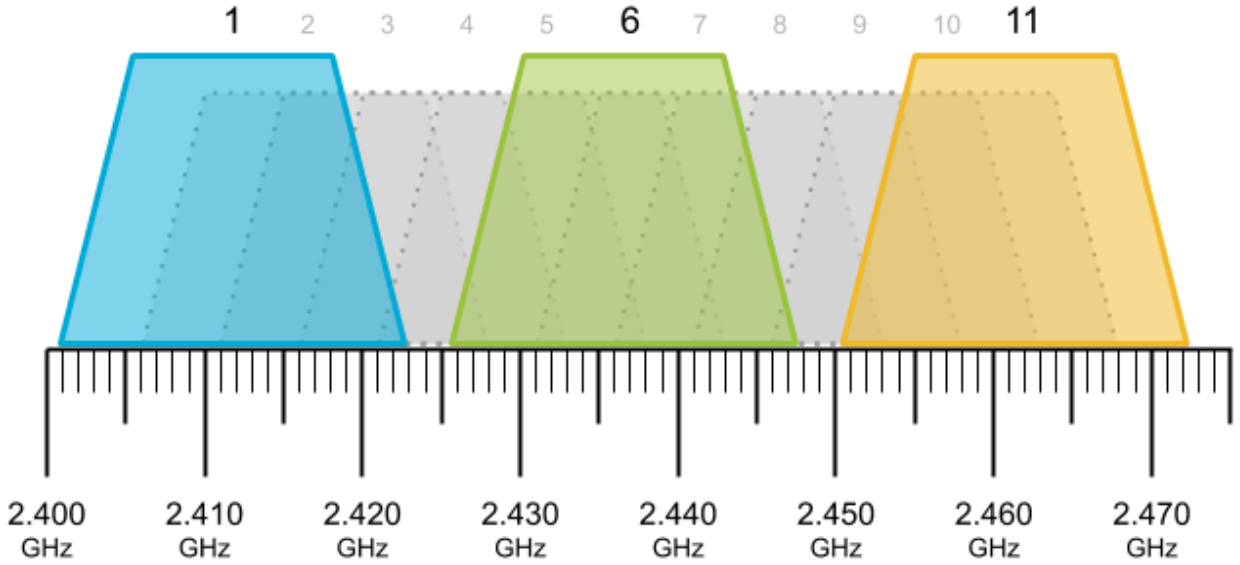


- wireless host communicates with base station
  - base station = access point (AP)
- Basic Service Set (BSS) (aka “cell”) in infrastructure mode contains:
  - wireless hosts
  - access point (AP): base station
  - ad hoc mode: hosts only

802.11: Channels

- spectrum divided into channels at different frequencies
  - AP admin chooses frequency for AP
  - interference possible: channel can be same as that chosen by neighboring AP!

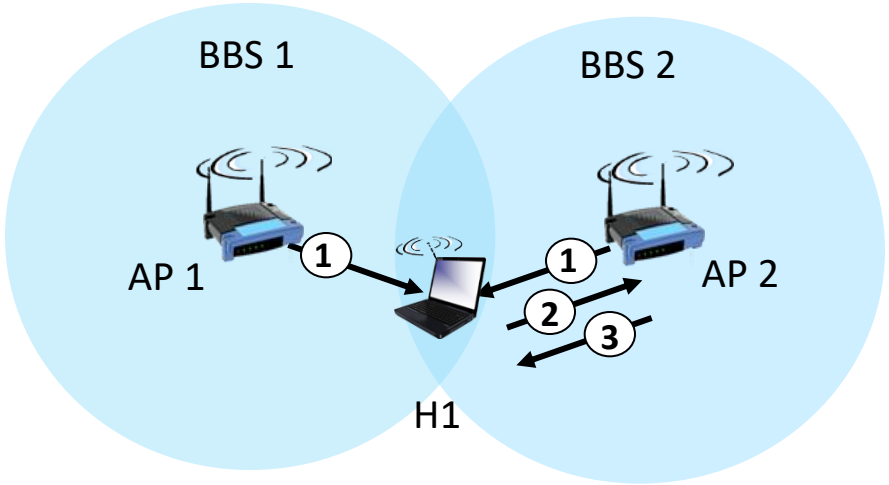
Example: 2.4 GHz

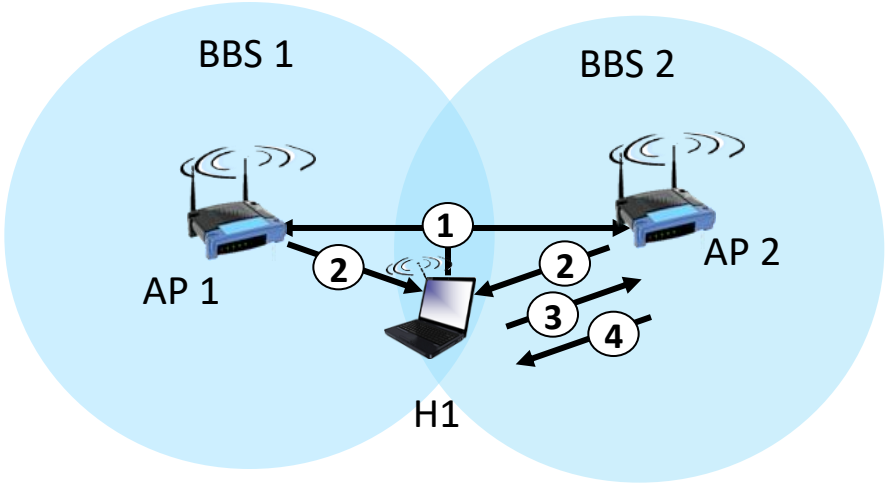


802.11: Association

- arriving host: must associate with an AP
  - scans channels, listening for *beacon frames* containing AP's name (SSID) and MAC address
  - selects AP to associate with
  - then may perform authentication
  - then typically run DHCP to get IP address in AP's subnet

802.11: passive/active scanning





passive scanning:

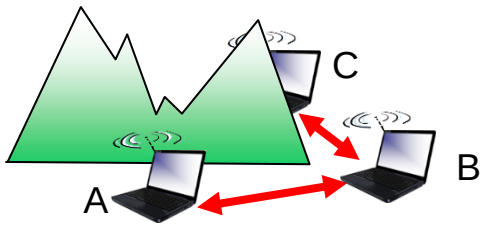
(1) beacon frames sent from APs
(2) association Request frame sent: H1 to selected AP
(3) association Response frame sent from selected AP to H1

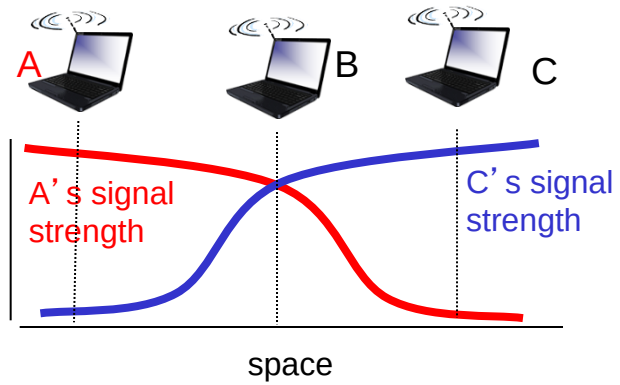
active scanning:

(1) Probe Request frame broadcast from H1
(2) Probe Response frames sent from APs
(3) Association Request frame sent: H1 to selected AP
(4) Association Response frame sent from selected AP to H1

IEEE 802.11: multiple access

- avoid collisions: 2^+ nodes transmitting at same time
- 802.11: CSMA - sense before transmitting
  - don't collide with detected ongoing transmission by another node
- 802.11: *no* collision detection!
  - difficult to sense collisions: high transmitting signal, weak received signal due to fading
  - can't sense all collisions in any case: hidden terminal, fading
  - goal: *avoid collisions:* CSMA/CollisionAvoidance





IEEE 802.11 MAC Protocol: CSMA/CA

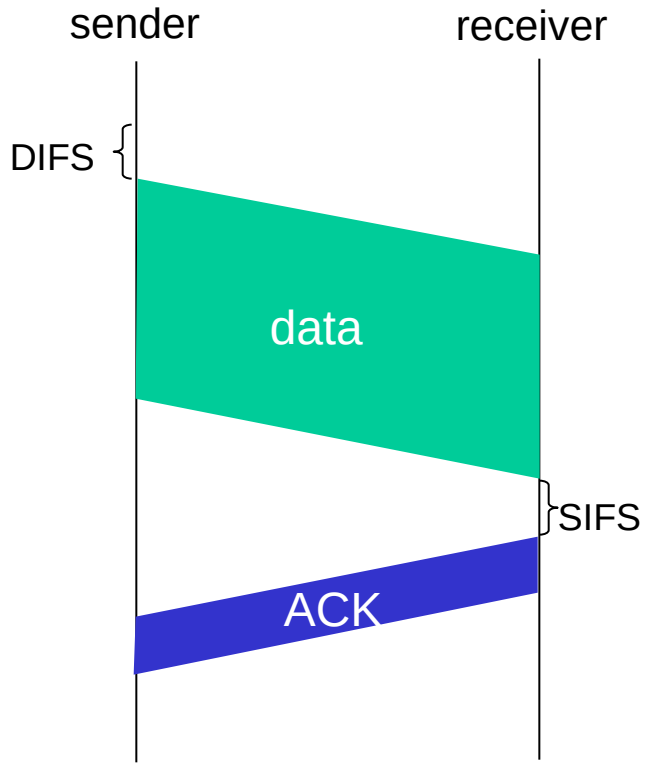
802.11 sender

1 if sense channel idle for **DIFS** then
transmit entire frame (no CD)

2 if sense channel busy then
start random backoff time
timer counts down while channel idle
transmit when timer expires
if no ACK, increase random backoff interval, repeat 2

802.11 receiver

if frame received OK
return ACK after **SIFS** (ACK needed due to hidden terminal problem)

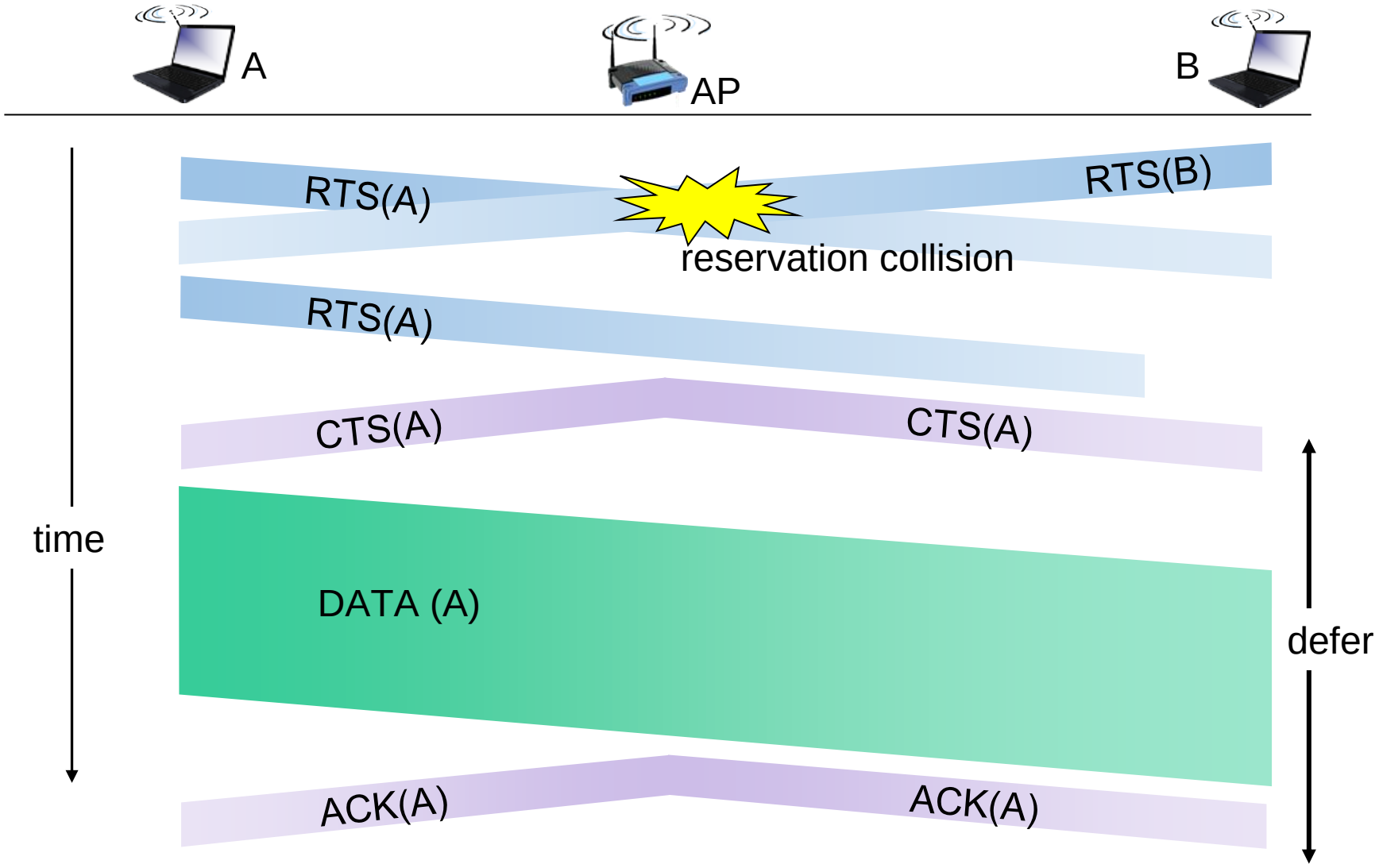


Avoiding collisions (more)

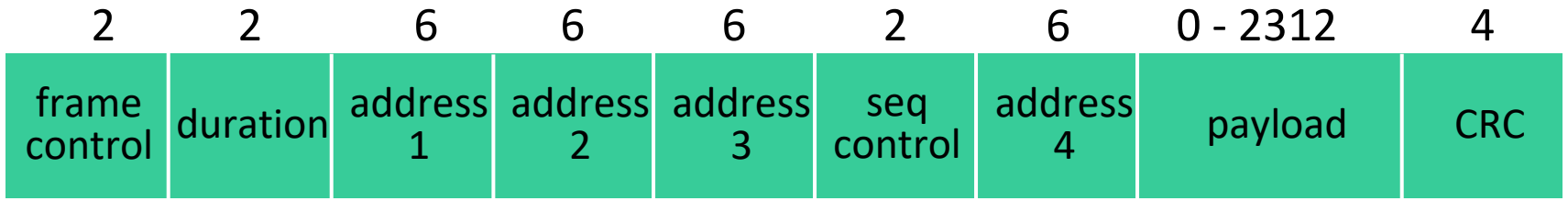
idea: sender “reserves” channel use for data frames using small reservation packets

- sender first transmits *small* request-to-send (RTS) packet to BS using CSMA
  - RTSs may still collide with each other (but they’re short)
- BS broadcasts clear-to-send CTS in response to RTS
- CTS heard by all nodes
  - sender transmits data frame
  - other stations defer transmissions

Collision Avoidance: RTS-CTS exchange



802.11 frame: addressing



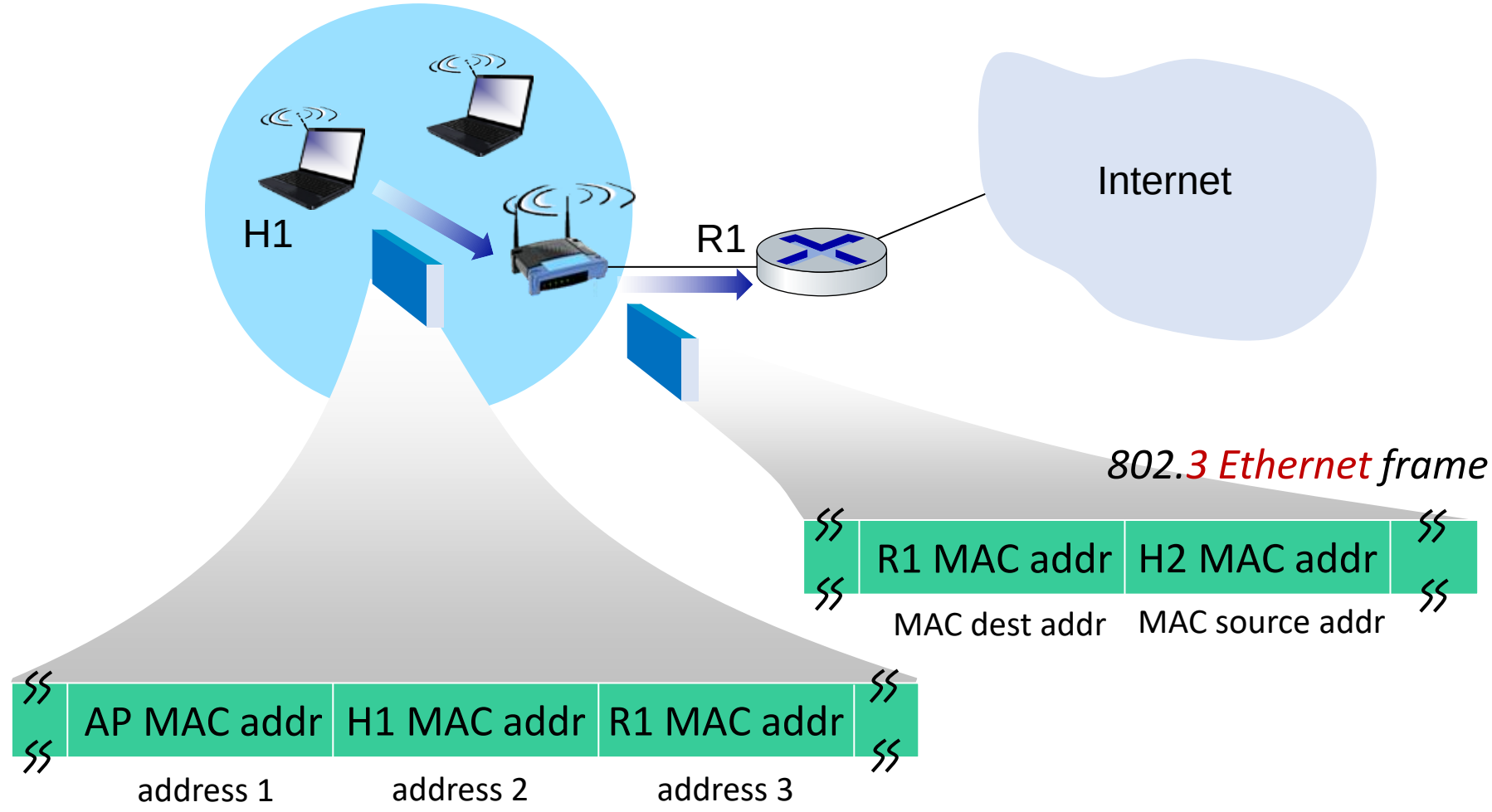
Address 1: MAC address of wireless host or AP to receive this frame

Address 2: MAC address of wireless host or AP transmitting this frame

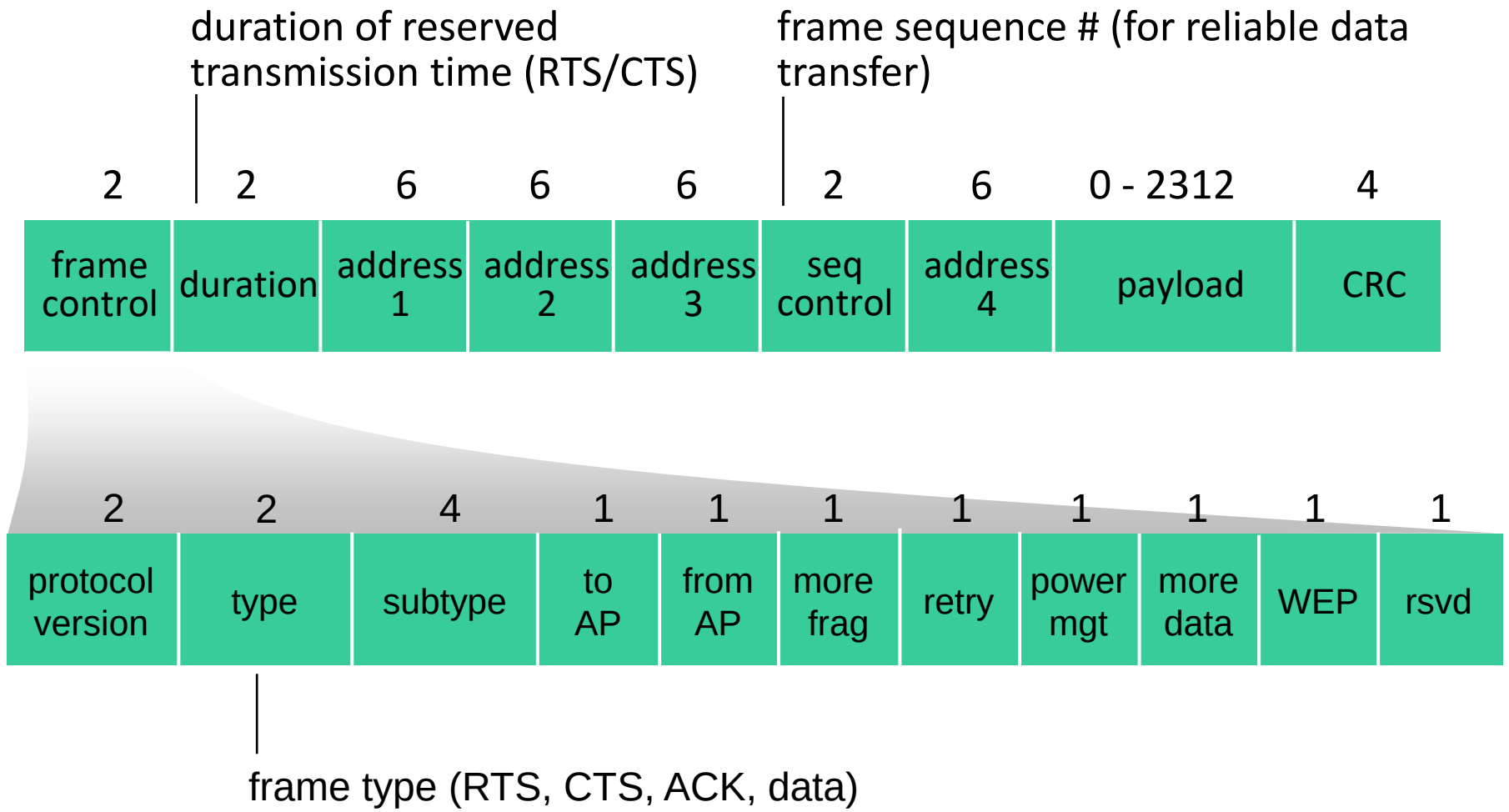
Address 3: MAC address of router interface to which AP is attached

Address 4: used only in ad hoc mode

802.11 frame: addressing

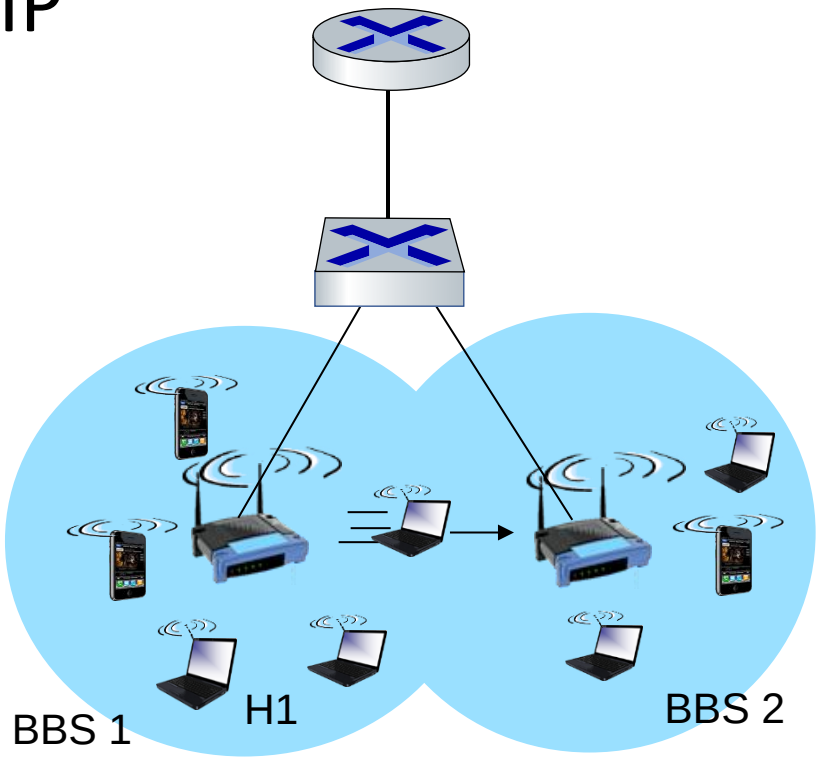


802.11 frame: addressing



802.11: mobility within same subnet

- H1 remains in same IP subnet: IP address can remain same
- switch: which AP is associated with H1?
  - self-learning: switch will see frame from H1 and "remember" which switch port can be used to reach H1



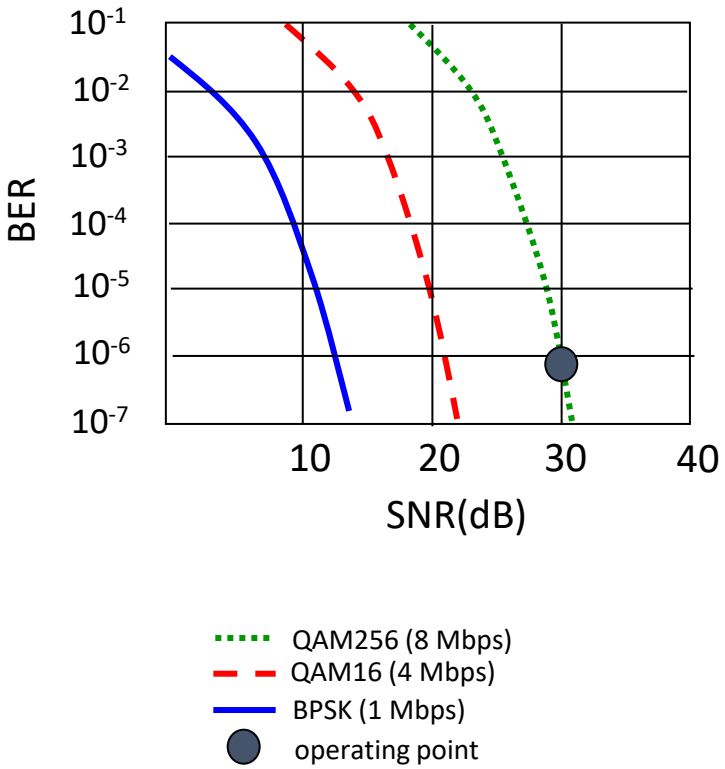
802.11: advanced capabilities

Rate adaptation

- base station, mobile dynamically change transmission rate (physical layer modulation technique) as mobile moves, SNR varies

  1. SNR decreases, BER increase as node moves away from base station

  2. When BER becomes too high, switch to lower transmission rate but with lower BER



802.11: advanced capabilities

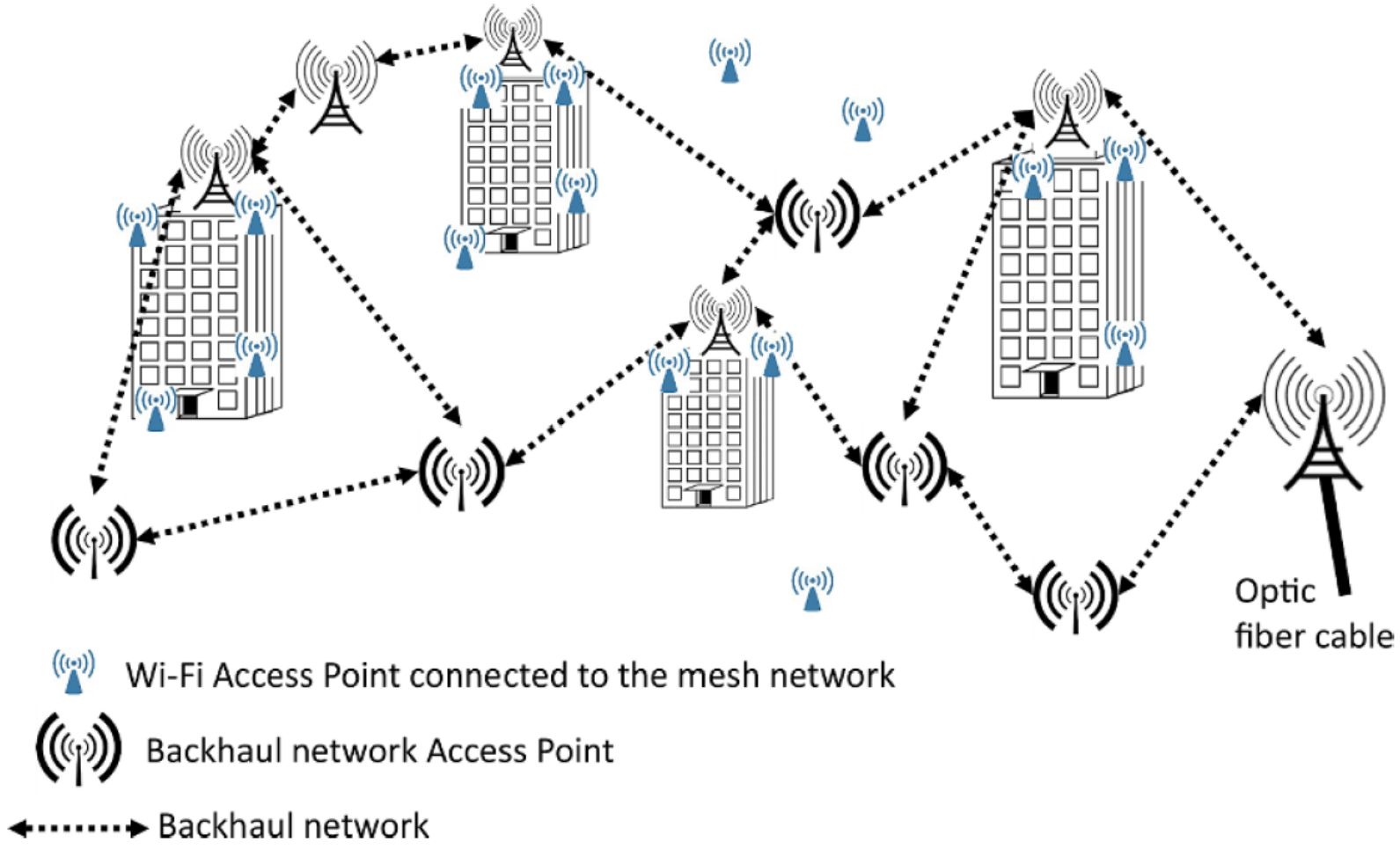
power management

- node-to-AP: “I am going to sleep until next beacon frame”
  - AP knows not to transmit frames to this node
  - node wakes up before next beacon frame
- beacon frame: contains list of mobiles with AP-to-mobile frames waiting to be sent
  - node will stay awake if AP-to-mobile frames to be sent; otherwise sleep again until next beacon frame

Small cells

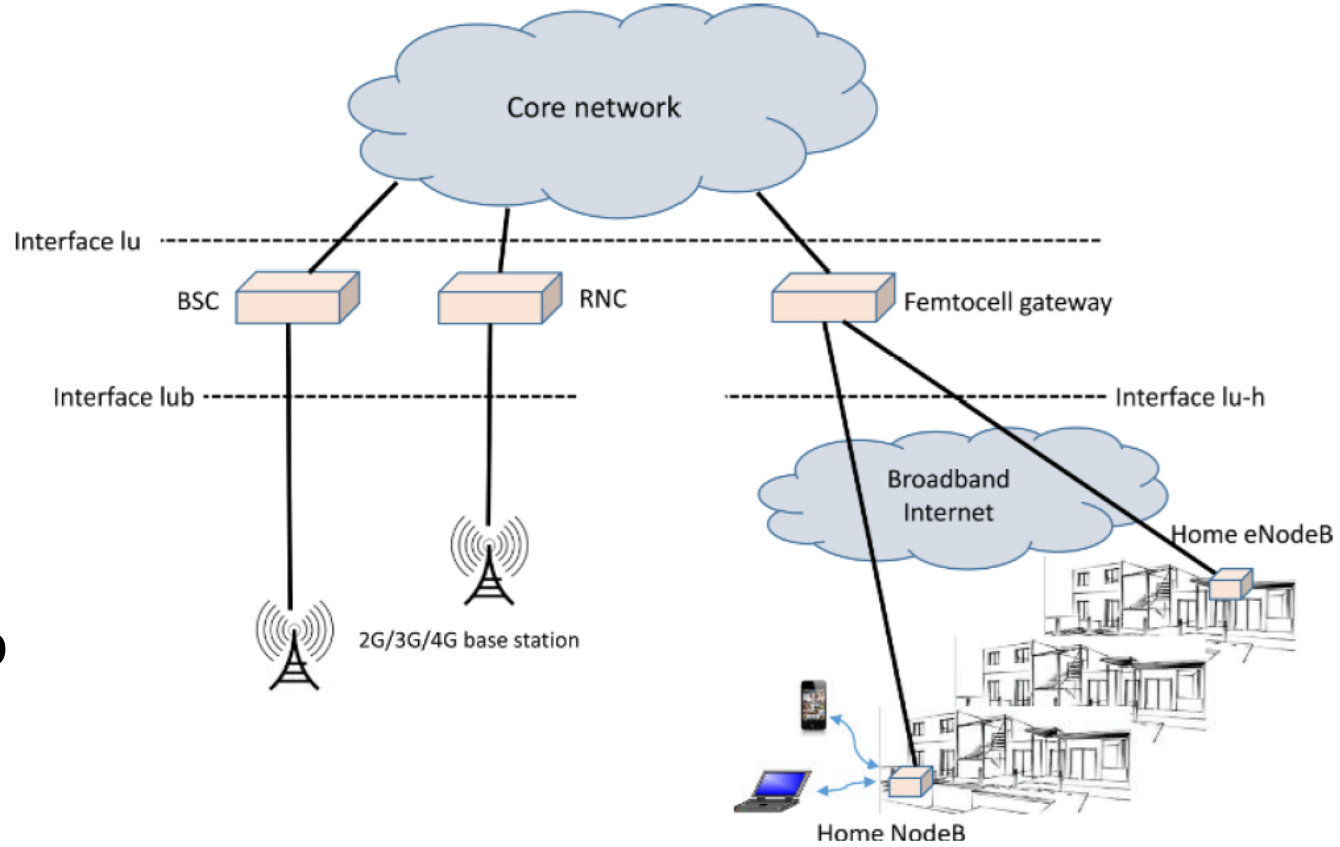
- The new generation of cells of very small dimensions
- Pros:
  - Reuse of frequencies
  - Lower energy consumption
  - Adaptation of cell size
- Various forms:
  - femtocells, which correspond to a home
  - metrocells, which provide coverage in the street
  - hotspots, which are set up in public spaces
  - picocells, for companies

Small cells and backhaul networks



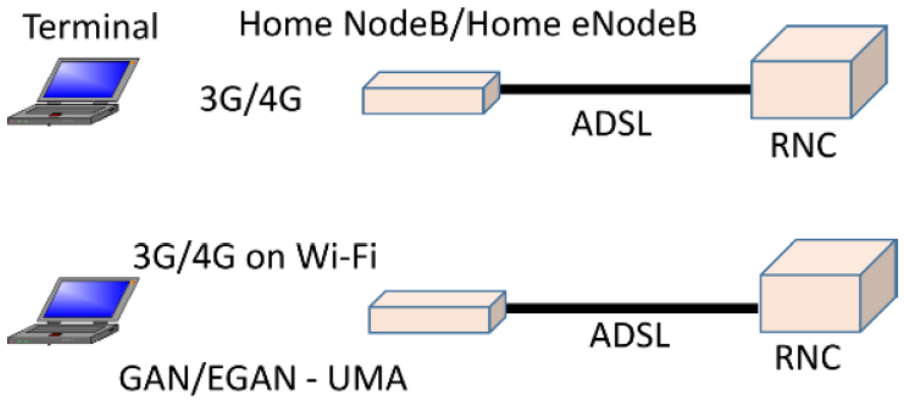
Femtocells

- Femtocell: antenna mounted on the user's home gateway
- Around ten meters (s.t. obstacles and interference)
- Multiplication of the cells, densification of the network, drop in the power of the devices
- The connection between the Home Gateway and the Femto Gateway uses fiber-optic technology, and often ADSL connection



Femtocells

- Two radio interfaces: Wi-Fi and “xG”



UMA – Unlicensed Mobile Access
RNC – Radio Network Controller
HNB – Home NodeB
HeNB – Home eNodeB

Hotspots

- Wi-Fi access points that facilitate Internet connection
- Open to all clients / through subscription
- Metrocells = small cells installed on the streets to handle 4G traffic
- Offloading purposes (alleviate the workload of the large antennas)
- The difficulty for a hotspot is to manage to offer QoS to the clients' applicational flows

Microcells & Wi-Fi Passpoint

Microcells:

- Designed for use by companies
- Provide access to intranet and internet, using two distinct SSIDs

Wi-Fi Passpoint:

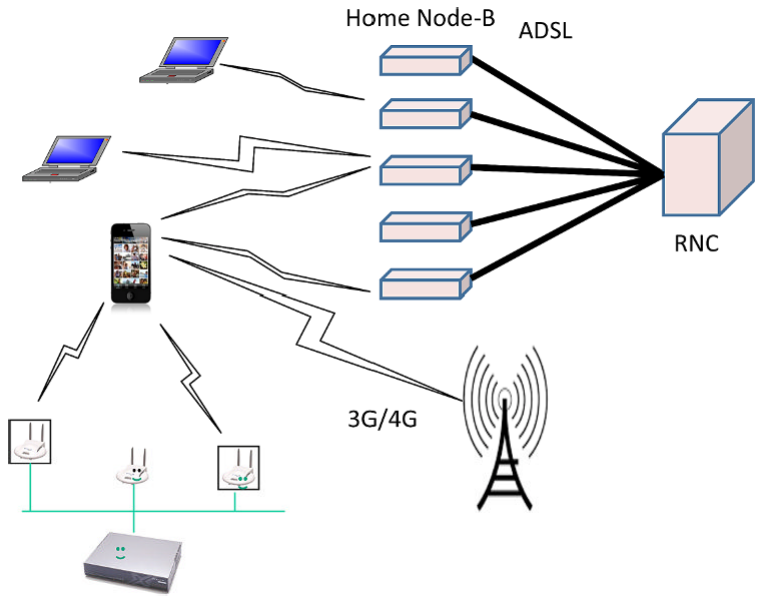
- Passpoint is a solution which helps to relieve the workload of “xG” antennas by offloading, giving users the option of connecting in a way that is totally transparent to the xG networks, using Wi-Fi

Wi-Fi Passpoint

- A program, installed on certified devices, automatically manages the network connection, authentication, authorization and underlying security in a manner which is totally transparent to the user
- Passpoint takes care of the discovery and selection of a network (s.t. user preferences, operator policies, network availability)
- The network connection takes place seamlessly
- Passpoint can also be used to instantaneously open accounts when the user does not have a subscription to a telecom operator
- Passpoint creates a global platform centered on four protocols based on EAP (Extensible Authentication Protocol)

Passpoint advantages

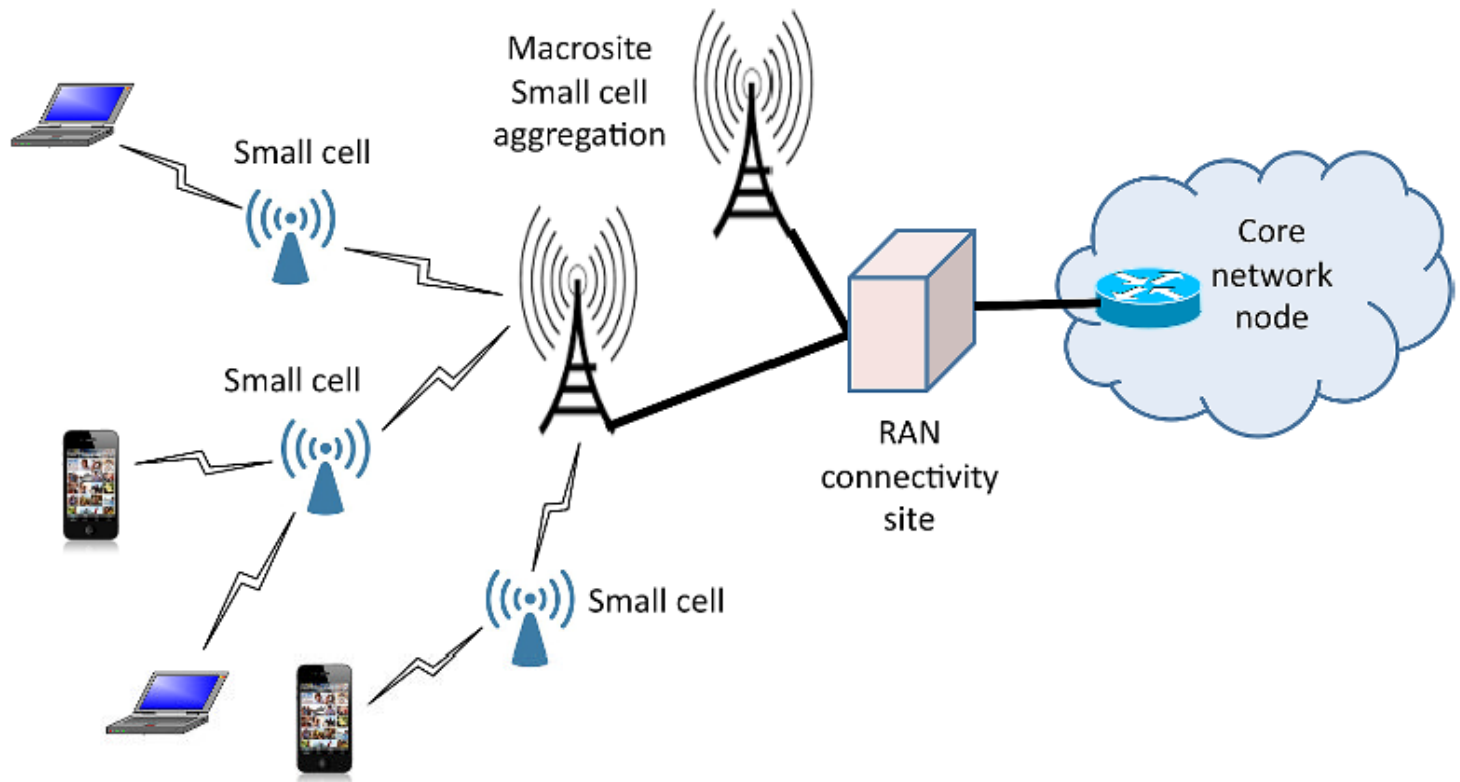
- Transparent authentication
- Offers Internet for electronic devices without a browser (cameras, onboard devices in cars, etc.)
- Offers simplicity of connection and creation of new subscriptions



Backhaul networks

- Backhaul networks form the intermediary networks between the access networks to which the clients are connected and the core
- Backhaul networks have essentially consisted of links between DSLAMs and the core network, or between Nodes-B and the core
- New trend: mesh networks, or networks of access points, in which the boxes are directly interconnected
- APs have two Wi-Fi ports: one to communicate with the neighboring access points, and the other to connect the clients

Backhaul networks

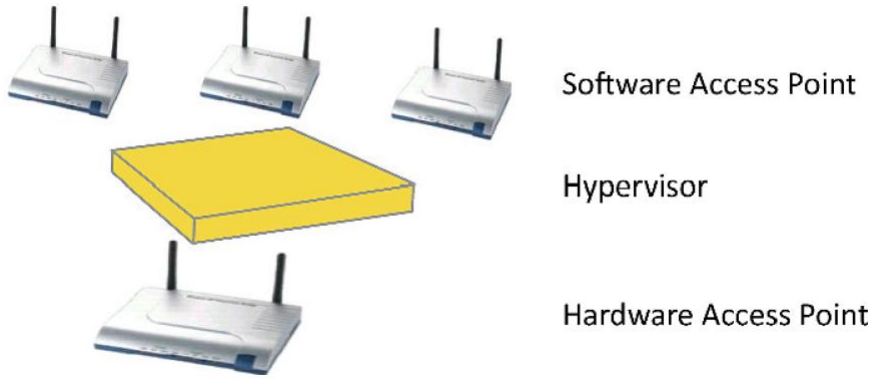


Software radio and radio virtual machine

- Software radio, or SDR (Software-Defined Radio), defines a radio transmitter or receiver which is in software, rather than hardware, form
- The computational power may be hosted on the device itself, or in the mobile Cloud, in a local Cloudlet, a regional Cloud or even a central Cloud
- Emergence of using a single antenna for all radio communications

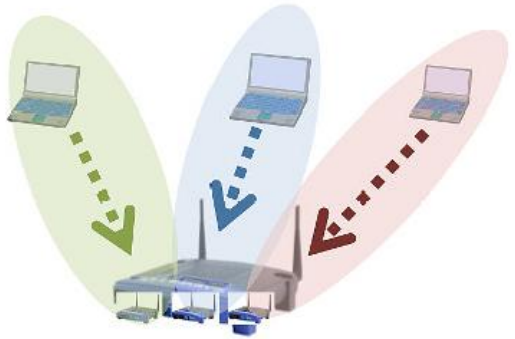
Virtualization in Wi-Fi

- Connections can be gathered together on virtualized shared APs, so as to avoid having to deploy a physical AP per small cell and per operator
- The physical antenna is shared among all virtual APs
- The physical box has a hypervisor upon which the VMs are founded



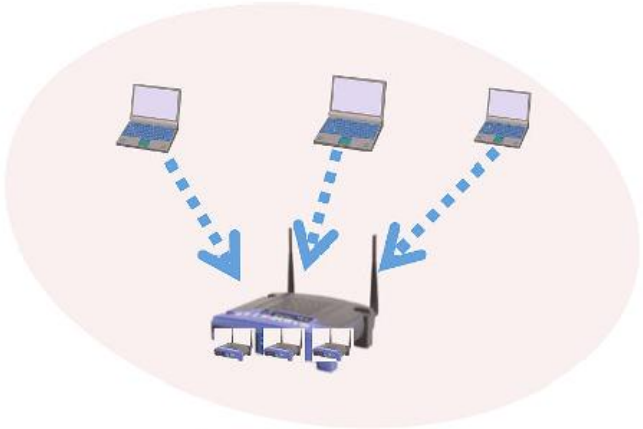
Other forms of virtualization

- A Home NodeB can be virtualized and play host to several operators without them competing for infrastructure
- Virtualization of APs leads to the creation of several cells which overlap one another and are served taking turns
- Packets have to pass through the same antenna one after another



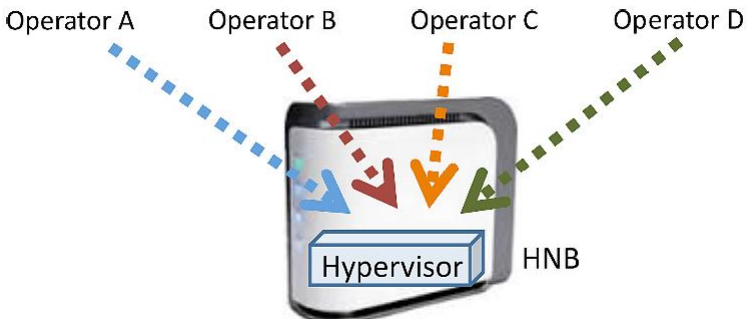
Spatial

Same operating system



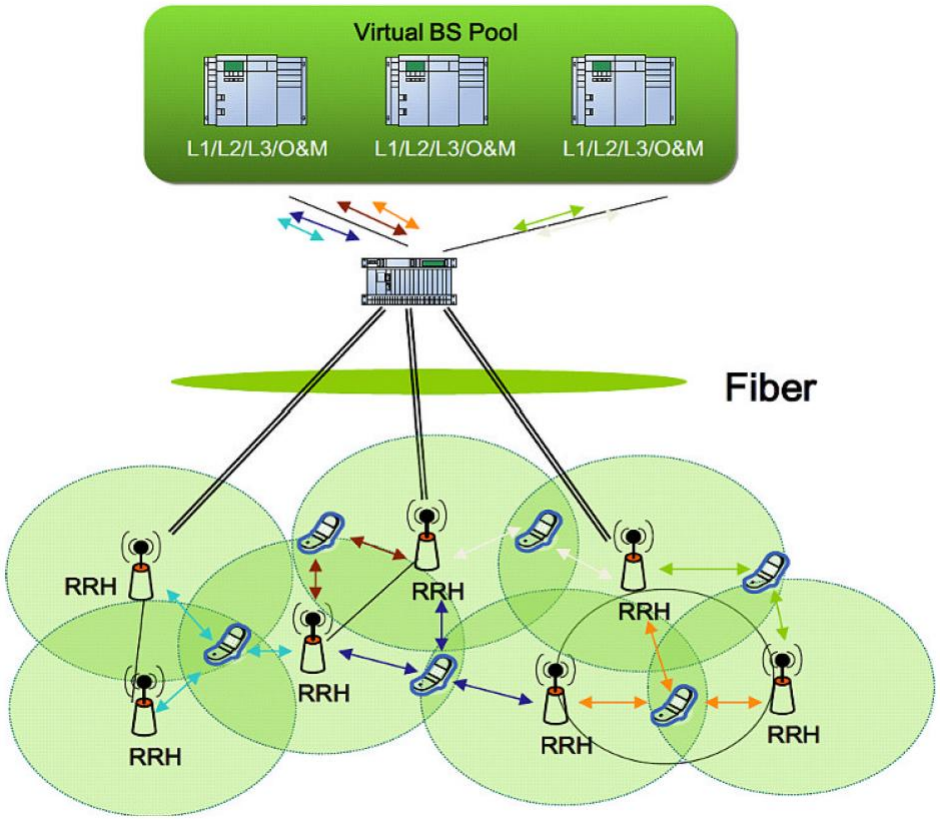
Temporal

Different operating systems



Cloud-Radio Access Network (C-RAN)

- All control algorithms are handled by datacenters
- The access network is eliminated completely, and replaced with a solution where the radio signal is sent directly to the datacenter
- Signal processing takes place in the Cloud
- The same antenna can be used for different signals (technologies)
- The Cloud unscrambles the signals



Mobile Cloud Networking (MCN)

- The basic element is the mobile terminal, which moves around and requests services from a Cloud which, for its part, is fixed

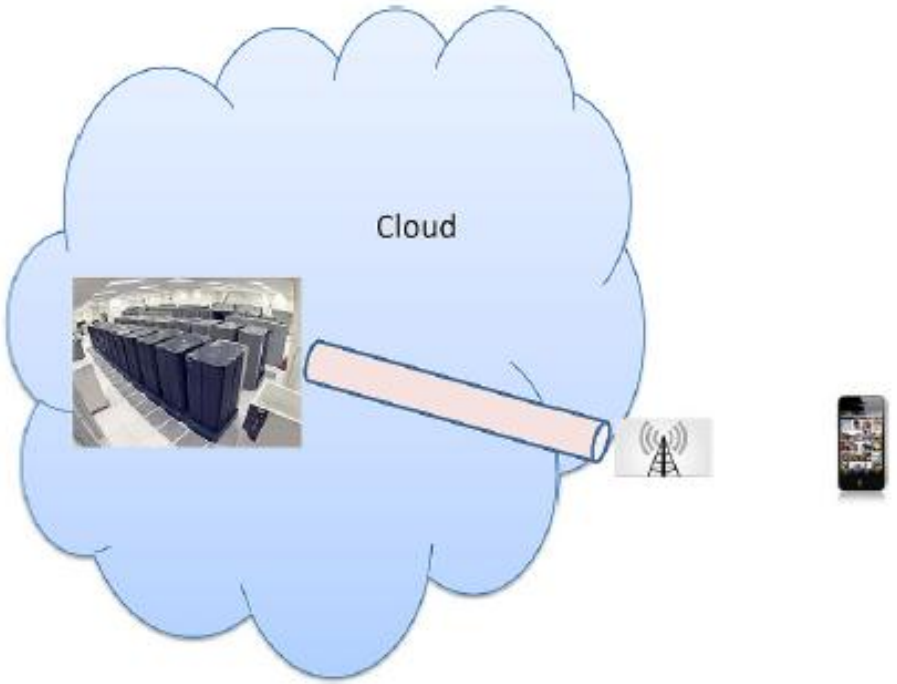
- Mobile Cloud refers to technologies where the Cloud itself is mobile

MCN perspectives

- There are two predominant orientations:
  - an **application orientation**, which means that a mobile device with limited resources is able to handle applications which require intensive computations or more memory than the terminal has
    - Mobile Cloud gaming / Mobile Game as a Service (MGaaS) / AR / Optical Character Recognitions applications / Natural language use
  - a **network orientation**, which involves the optimization of algorithms for the control of mobile services
    - Firewalls / Handover control / Mobile attachment

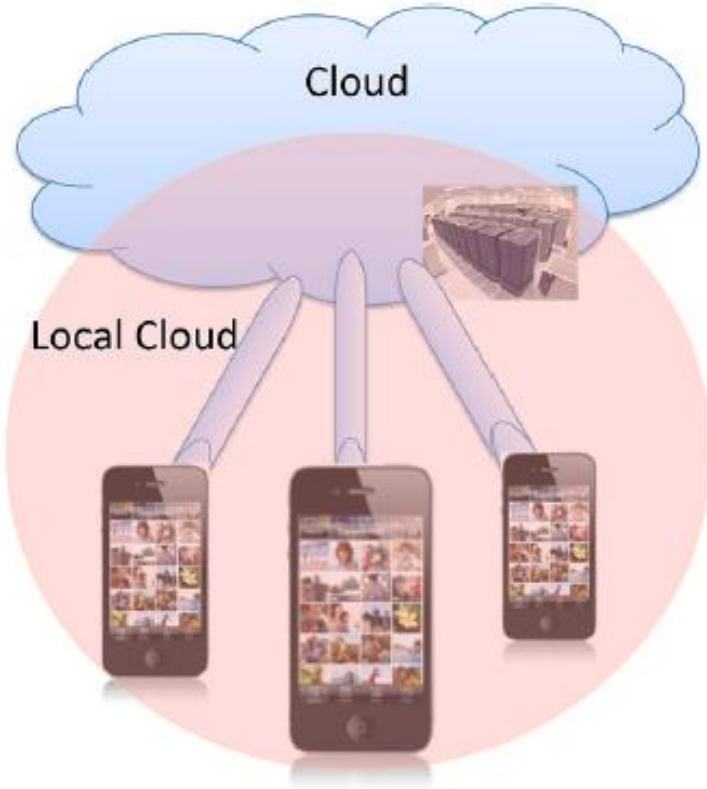
MCN architectures – Option 1

- Mobile phone (lightweight) using a central Cloud to handle “hungry” applications:
  - CPU intensive
  - High memory requirements
  - Resources for Big Data



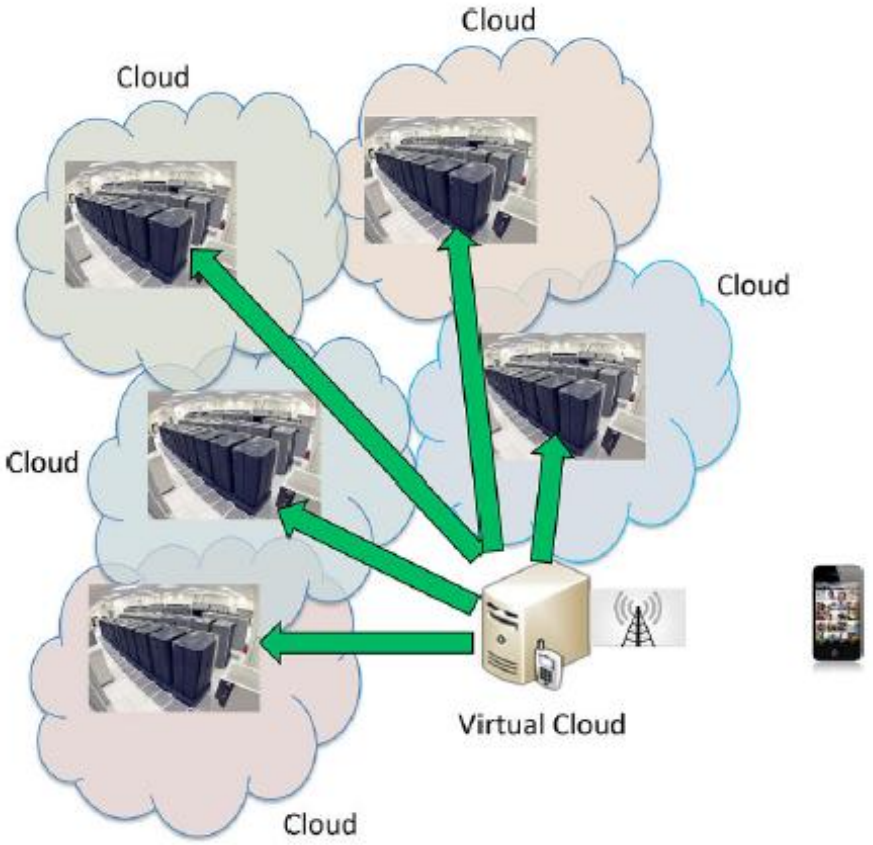
MCN architectures – Option 2

- Cloud is no longer central but local or at least not too far from the user
- The resources can be hosted on other mobile devices
- Neighboring mobile devices may form a Cloud
- Loal datacenter required (e.g. at DSLAM or home GW)



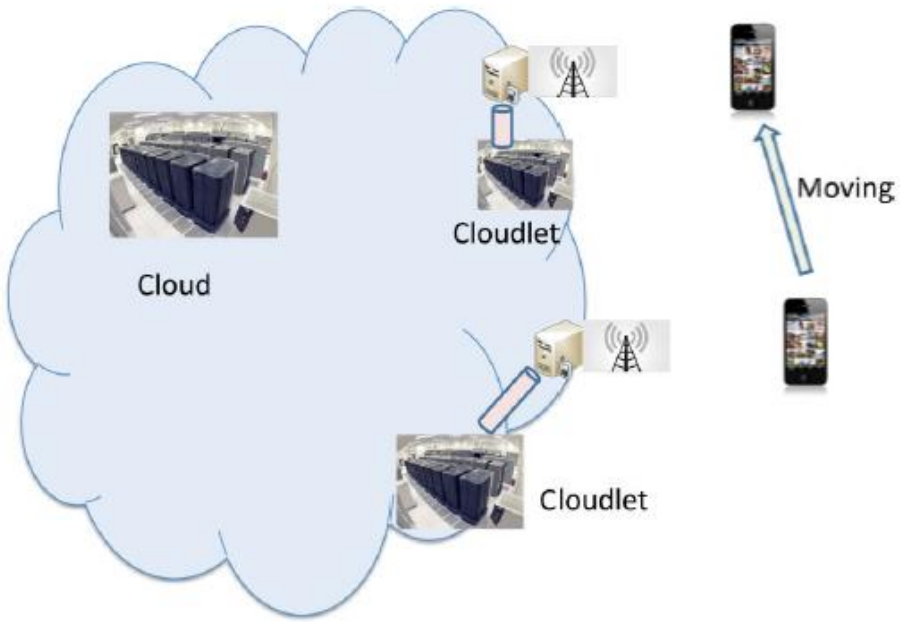
MCN architectures – Option 3

- Virtual Cloud concept
- Single Cloud usually insufficient to contain all requested services => user requests connection to several Cloud providers
- “Intermediary” server or “Sky” provider with extensive knowledge of all the Clouds => can choose the best Cloud



MCN architectures – Option 4

- Small cloud or “Cloudlet” which moves with the client
- Actually, the connection to different Cloudlets gives that impression
- Handover = terminal attaches to a new Cloudlet
- Cloudlet = concept of a small Cloud situated in a zone with a very high demand



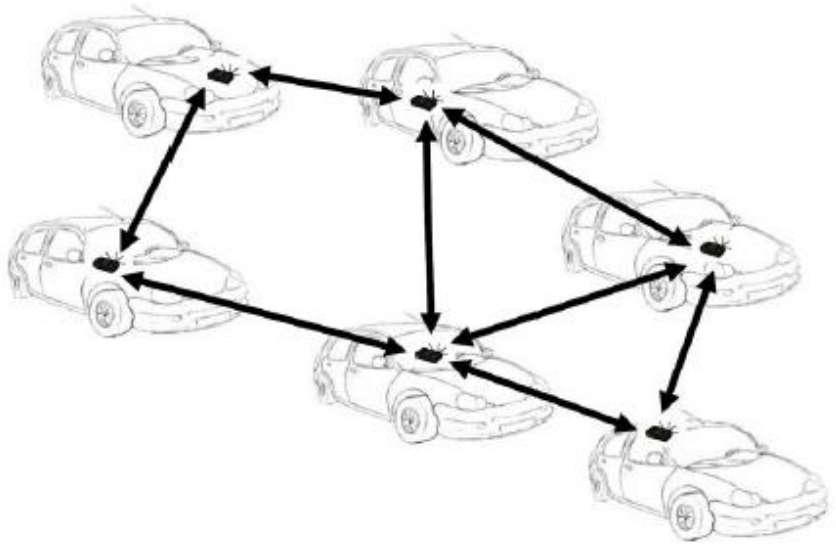
Optimization criteria to build hierarchy of Clouds

- performance and reliability of applications for mobiles
- performance of control applications for mobiles
- minimization of energy consumption by the terminals, datacenters, etc.
- availability
- high security:
  - m-commerce
  - m-Cloud access
  - m-payment

Mobile Clouds

- Mobile Cloud = a set of small datacenters which form a Cloud
- Challenge: mobility of such Cloudlets, attach/detach
  - If they move simultaneously → VANET (Vehicular Area Network) supports the mobile Cloud
  - If they move independently & uncoordinated → difficulty in forming the mobile Cloud

Each vehicle has its own femto-datacenter



Mesh or ad-hoc network

Examples of mobile clouds

Thank you!