

Data Link Layer-6

16.12.2019

BLM 305 I Network Layer & Next Generation Wireless Networks

-Short Introduction-

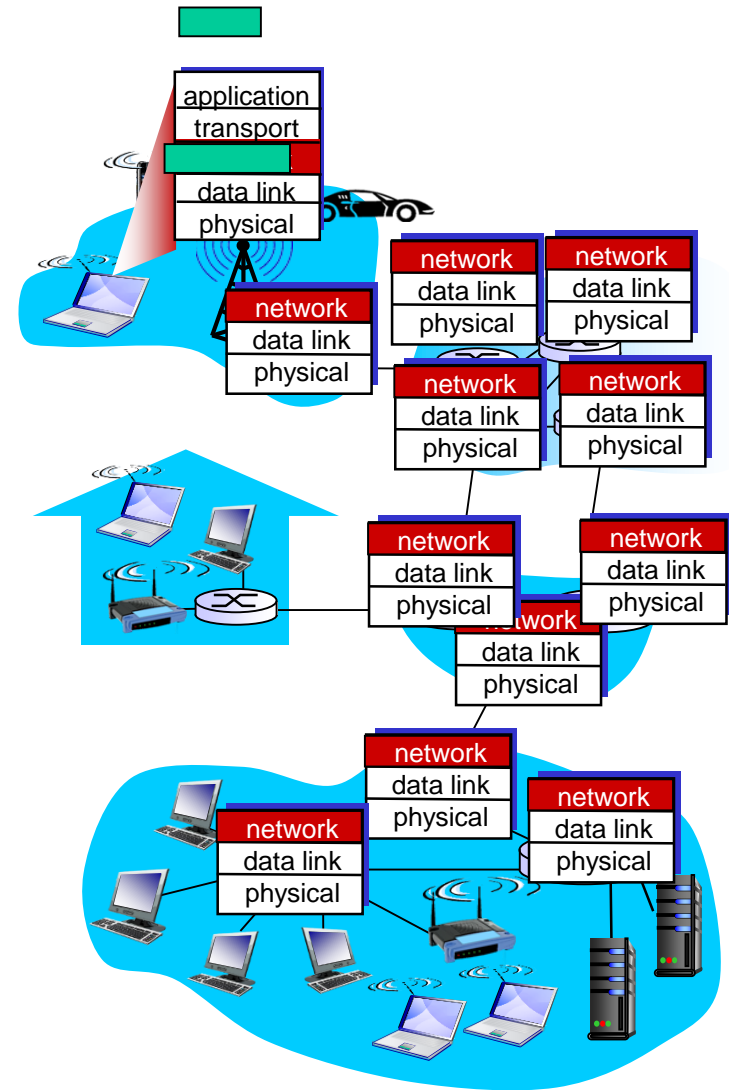
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Assoc. Prof. Dr. Veli Hakkoymaz

References:

- *Computer Networks*, Andrew Tanenbaum, Pearson, 5th Edition, 2010.
- *Computer Networking, A Top-Down Approach Featuring the Internet*, James F.Kurose, Keith W.Ross, Pearson-Addison Wesley, 6th Edition, 2012.
- **BLG337 Slides** from İTÜ prepared by Assoc. Prof.Dr. Berk CANBERK

Network Layer

- ✓ transport segment from sending to receiving host
- ✓ on sending side encapsulates segments into datagrams
- ✓ on receiving side, delivers segments to transport layer
- ✓ network layer protocols in **every** host, router
- ✓ router examines header fields in all IP datagrams passing through it



Network Layer

- Concerned with getting packets from source to destination
- Network layer must
 - know the subnet topology and
 - choose appropriate paths through it
- When source and destination are in different networks, network layer must handle
- Services provided to Transport Layer:
 - Should be independent of the subnet topology
 - Should be independent of the router
 - Transport Layer should be shielded from the number, type and topology of the subnets present
 - The network addresses available to the Transport Layer should use a uniform numbering plan

Network Layer :

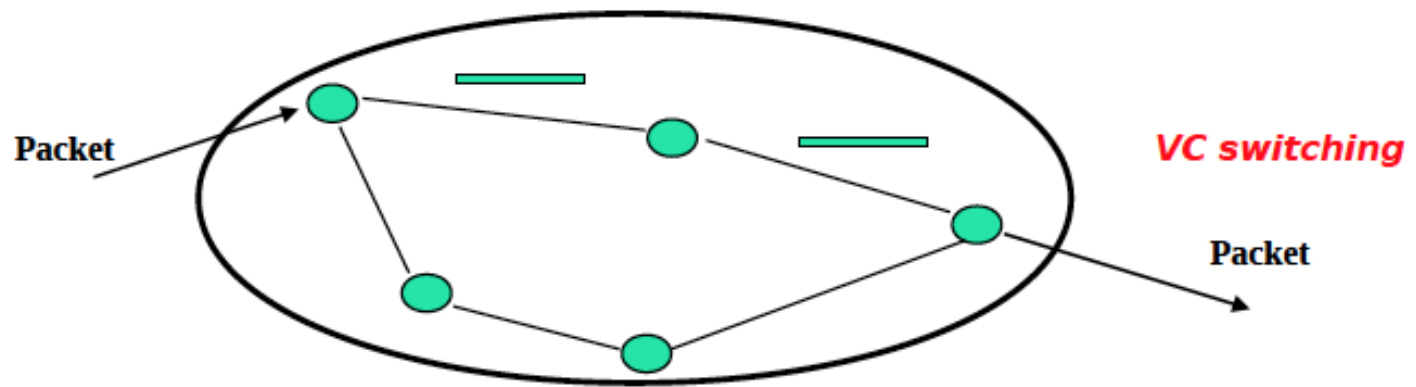
Connection&Connection-less Service

- ✓ **Datagram Network** provides network-layer **connection-less service**
- ✓ **VC (Virtual Circuit) Network** provides network-layer **connection service**

Connection – Oriented (VC Networks)

“source-to-dest path behaves much like *telephone circuit*”

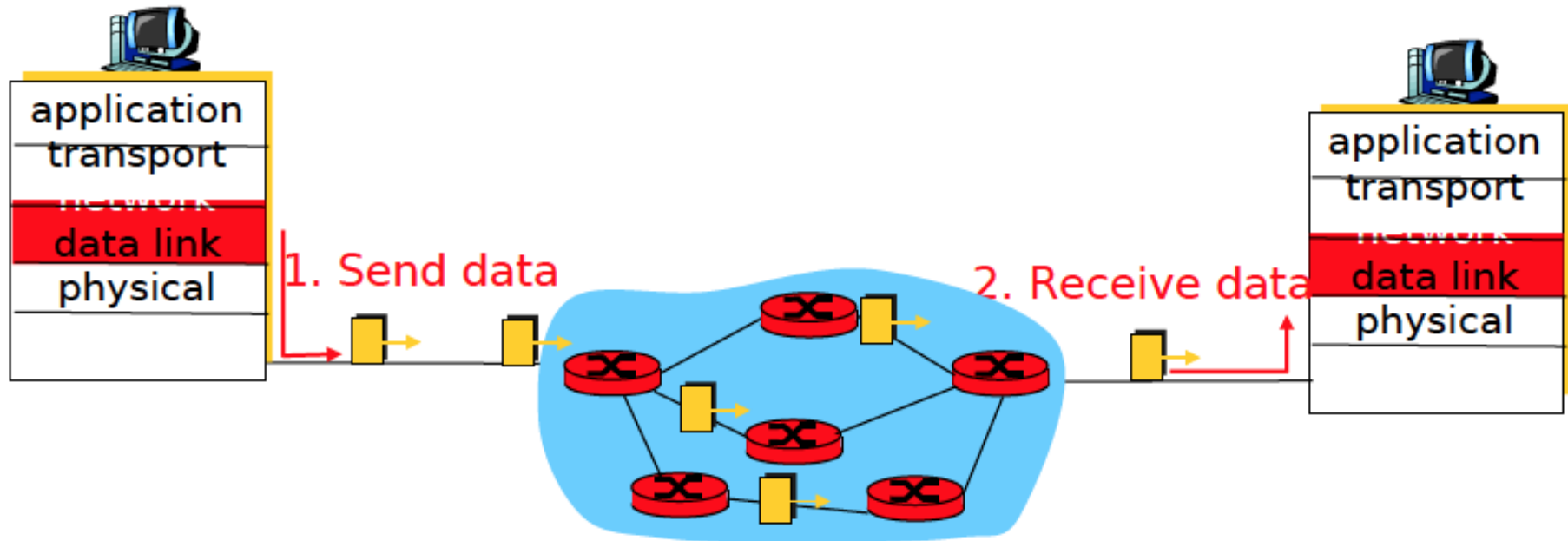
- performance-wise
- network actions along source-to-dest path

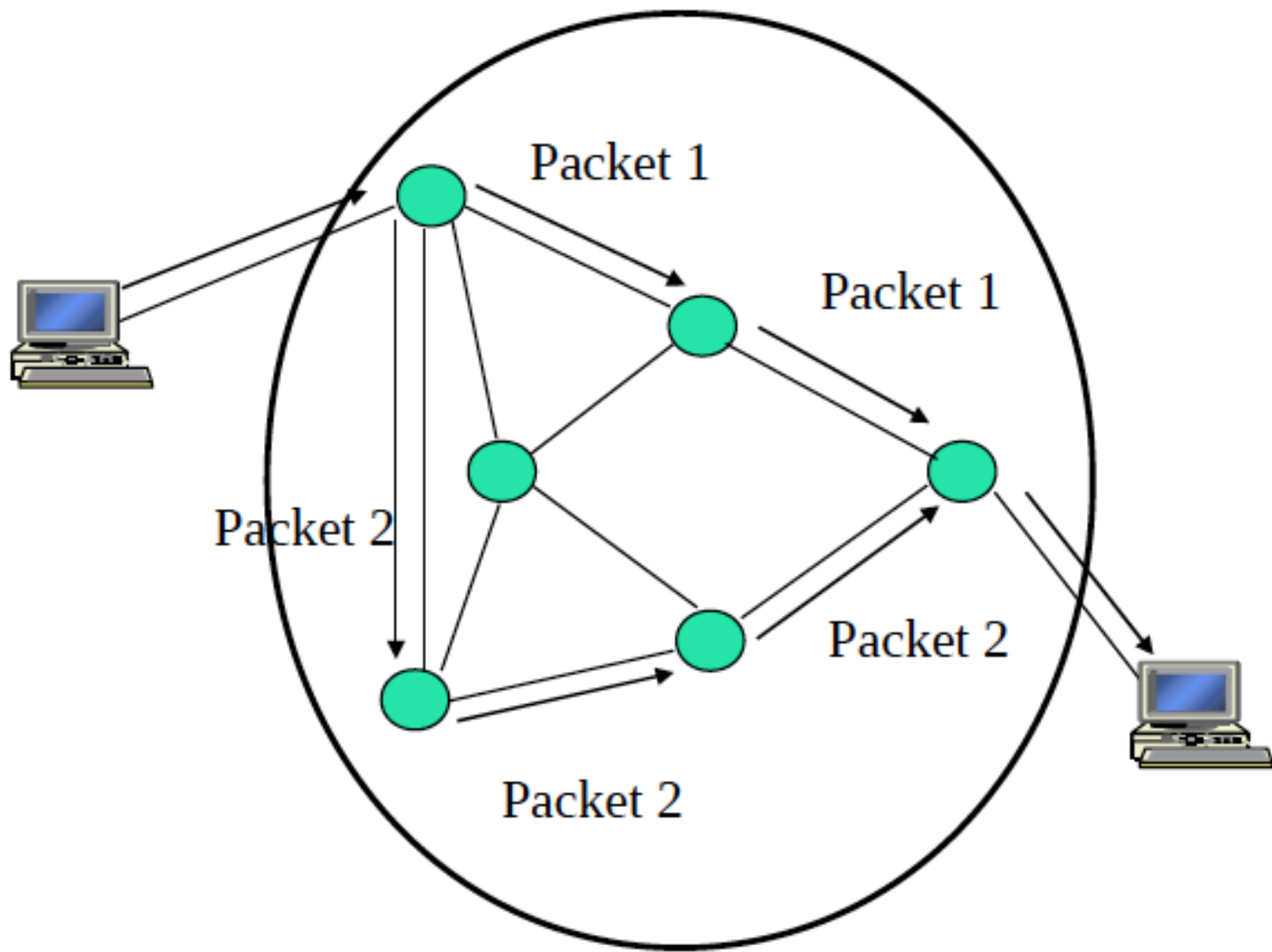


- call setup, teardown for each call *before* data can flow
- each packet carries VC identifier (not destination host address)
- routers on source-dest path maintains “state” for each passing connection
- link, router resources (bandwidth, buffers) may be *allocated* to VC

Connectionless (Datagram Networks)

- no call setup at network layer
- routers: do not maintain state for e2e connections
 - no network-level concept of “connection”
- packets forwarded using destination host address
 - packets between the same source-dest pair may take different paths





Routing

- ***Routing algorithm*** : Part of the Network Layer responsible for deciding on which output line to transmit an incoming packet.
 - **Remember**: For virtual circuit subnets the routing decision is made ONLY at setup
- **Algorithm properties**:
 - Efficiency, correctness, simplicity, robustness, stability, fairness, optimality, and scalability

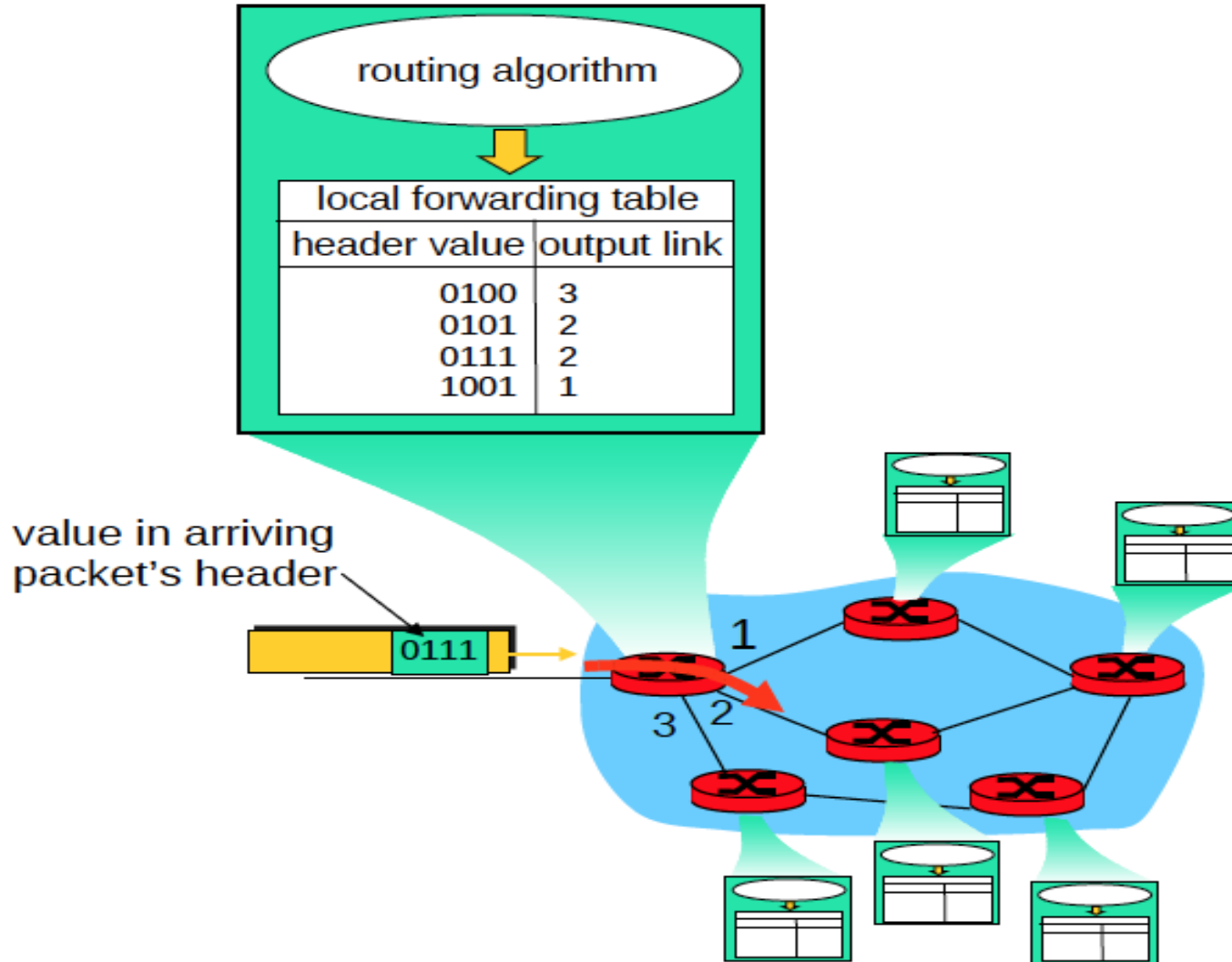
Key Network-Layer Functions

- *routing*: determine route taken by packets from source to dest
- *forwarding*: move packets from router's input to appropriate router output

Analogy:

- *routing*: process of planning trip from source to dest
- *forwarding*: process of getting through single interchange

Key Network-Layer Functions



Routing Table

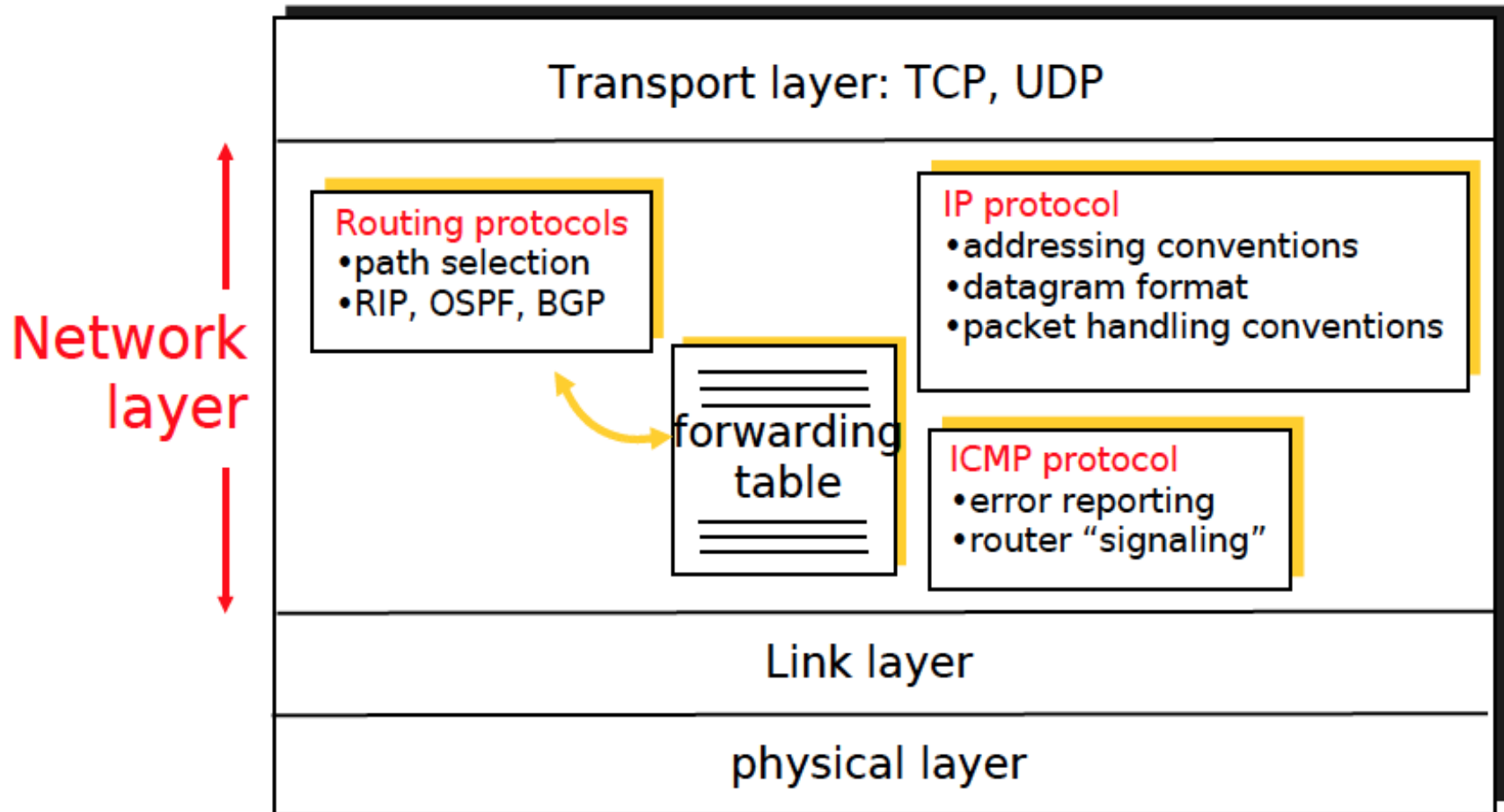
Destination address	Output port
0785	7
1345	12
1566	6
2458	12

Elements of Routing Techniques

- Performance criteria: Used for selection of routes
 - # of hops, cost, delay, throughput
- Decision Place:
 - Distributed (each node)/Centralized/Source routing
- Decision Time: Packet or VC basis
- Network Information Source:
 - None, local, adjacent node, all nodes
- Network Information Update:
 - Continuous, periodical, on change

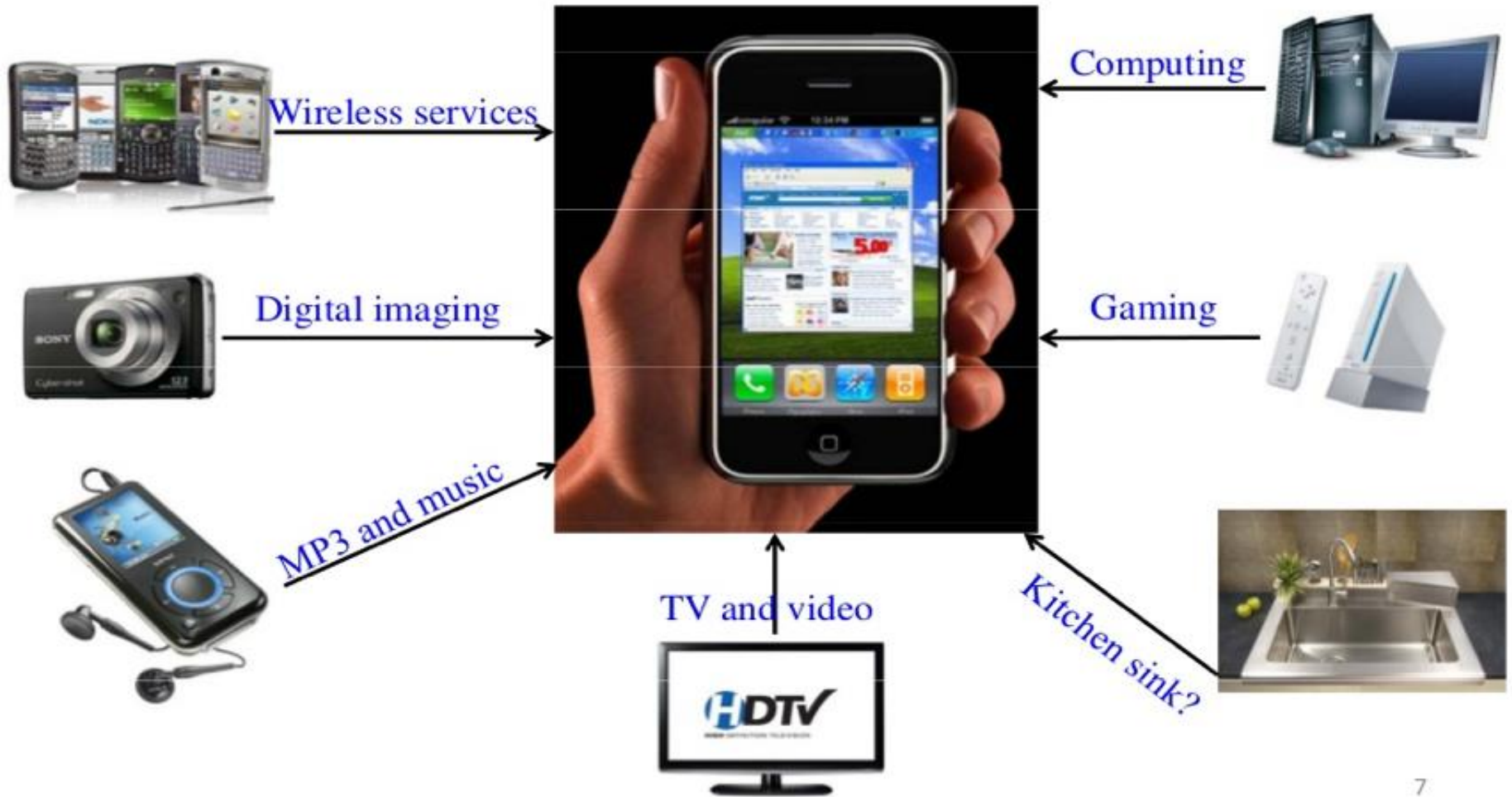
The Internet Network Layer

Host, router network layer functions:

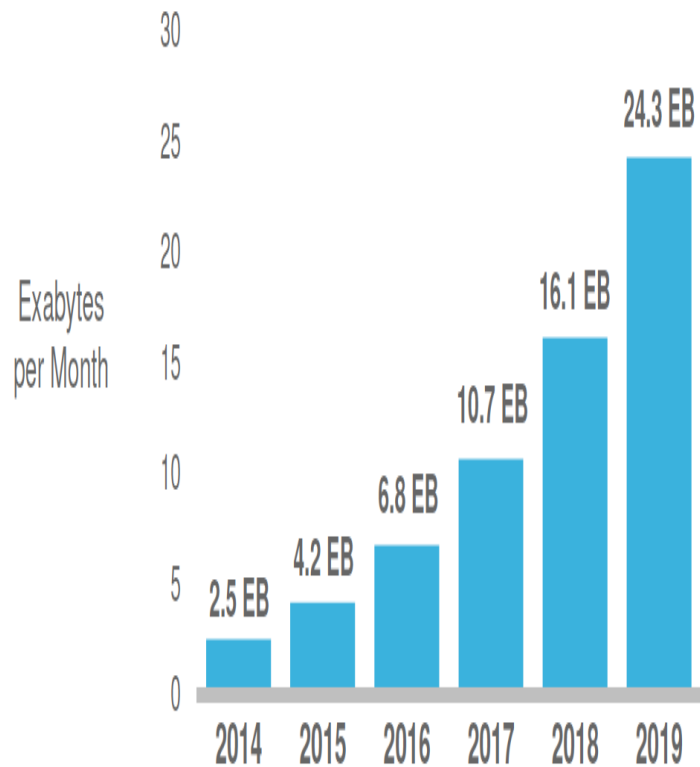


-Next Generation Wireless Networks-

Technology Convergence

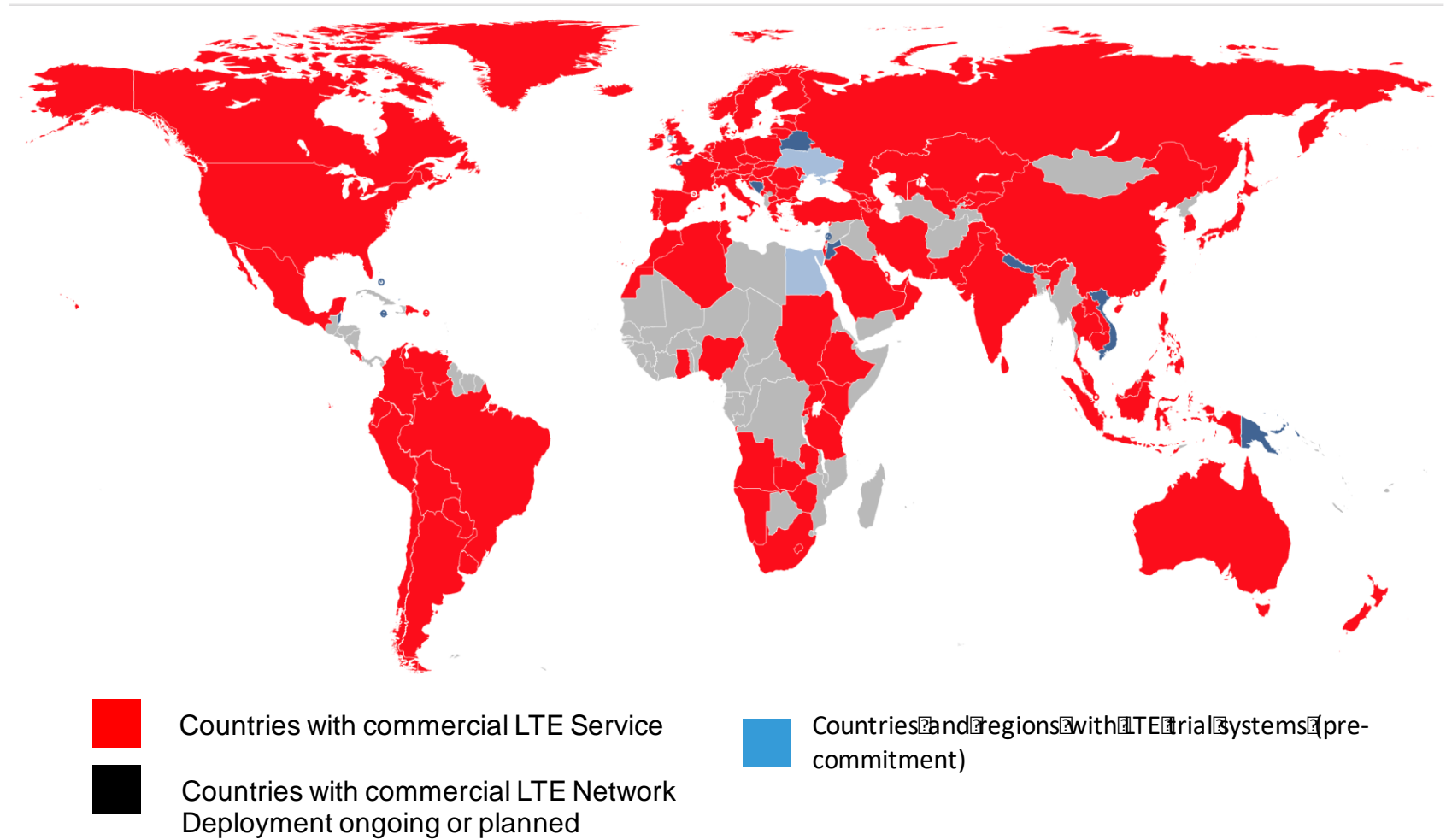


Motivations: Growth of Internet Data Traffic



- ✓ In 2015, wireless devices accounted for the **48%** of IP traffic.
- ✓ **Traffic from wireless and mobile devices will account for two-thirds of total IP traffic by 2020.**
- ✓ Mobile data traffic will increase **eightfold** between 2015 and 2020.
- ✓ Smartphone traffic **will exceed PC traffic by 2020.**

Countries with Commercial LTE Service



Source: [https://en.wikipedia.org/wiki/LTE_\(telecommunication\)](https://en.wikipedia.org/wiki/LTE_(telecommunication))

Some Coverage Maps : 2G/3G Turkey

Date: Dec 05, 2017

Source: OpenSignal, <https://opensignal.com/networks/>



Some Coverage Maps : 4G Turkey

Date: Dec 05, 2017

Source: OpenSignal, <https://opensignal.com/networks/>



Current Situation in Networking Usage

✓ **In one hour, around the globe;**

- -750 million SMS messages
- -148 million Google searches
- -10 million tweets
- -1.3 million mobile apps downloaded
- -3180 hours of Youtube videos uploaded
- -50000 smart phones activated

So how to handle this?

- ✓ One effective solution → **Group, Cluster, Classify wireless users according to**
 - Their geographic positions (indoor, outdoor, rural, urban, airport, malls, streets etc..)
 - Their traffic usage (Data, Voice, Video, etc)
 - Their Types of wireless technology they use (3G, 4G, WiFi, Bluetooth etc)

Mobile Network Technology Evolution

- ✓ 1989
 - GSM Radio Access Network (2G)
- ✓ 1998
 - GSM EDGE integration (2.5G- 2.75G)
- ✓ 1999
 - UMTS, HSxPA Terrestrial Radio Access Network (3G)
- ✓ 2004
 - 4G (LTE)
- ✓ 2011
 - LTE-Advanced
- ✓ Non 3GPP
 - Wifi (IEEE 802.11x, 1991-1999)
 - WiMAX (IEEE 802.16x, (2005)

LTE and LTE - Advanced

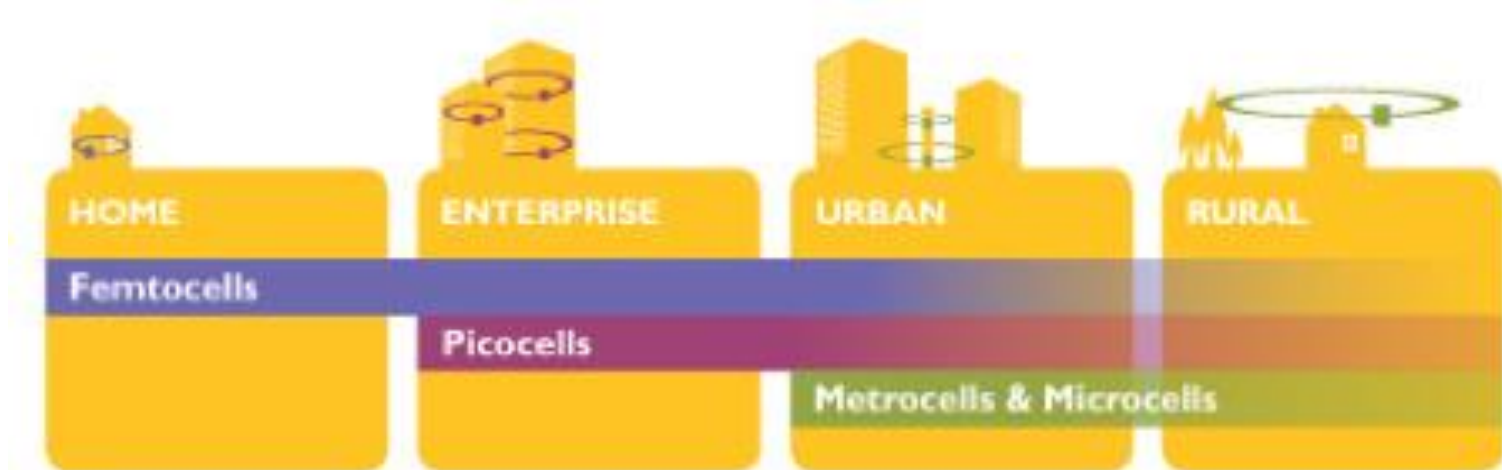
- ✓ Long Term Evolution (LTE) is the latest step in moving forward from the cellular 3G services .
- ✓ LTE is based on standards developed by the 3rd Generation Partnership Project (3GPP).
- ✓ LTE and LTE – Advanced may also be referred more formally as Evolved UMTS Terrestrial Radio Access (E-UTRA) and Evolved UMTS Terrestrial Radio Access Network (E-UTRAN).

What is a Small Cell?

- ✓ Small cells are low-power wireless access points that operate in licensed spectrum.
- ✓ They are operator-managed.
- ✓ They are features in an edge-based intelligence

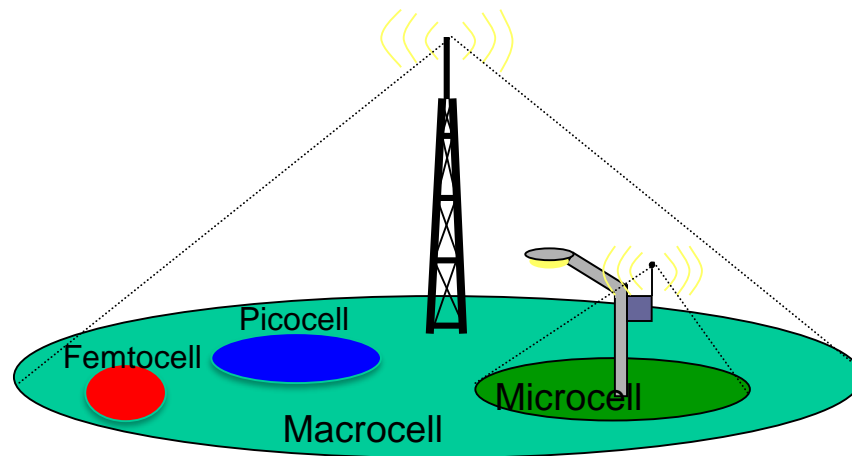
What is a Small Cell?

- ✓ According to their coverage: **From Macro to Femto**
 - -Metrocells
 - -Microcells
 - -Picocells
 - -Femtocells



Clustering Cells

- ✓ **Macrocell** → 10 km
- ✓ **Microcell** → 2 km (dedicated backhalls since deployed by operators)
- ✓ **Picocell** → 200 m (16-32 users) (dedicated backhalls since deployed by operators)
- ✓ **Femtocell** → 10 m (4-8 users) (popped-up by users, connected to operators through DSL/Cable/Ethernet)



Standards

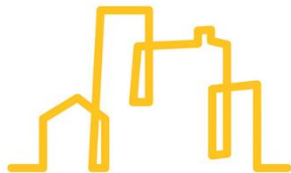
✓ 3GPP (3rd Generation Partnership

- Version 8, 2009 □ 3G Home NodeB



✓ Small Cell Forum (Femto Forum)

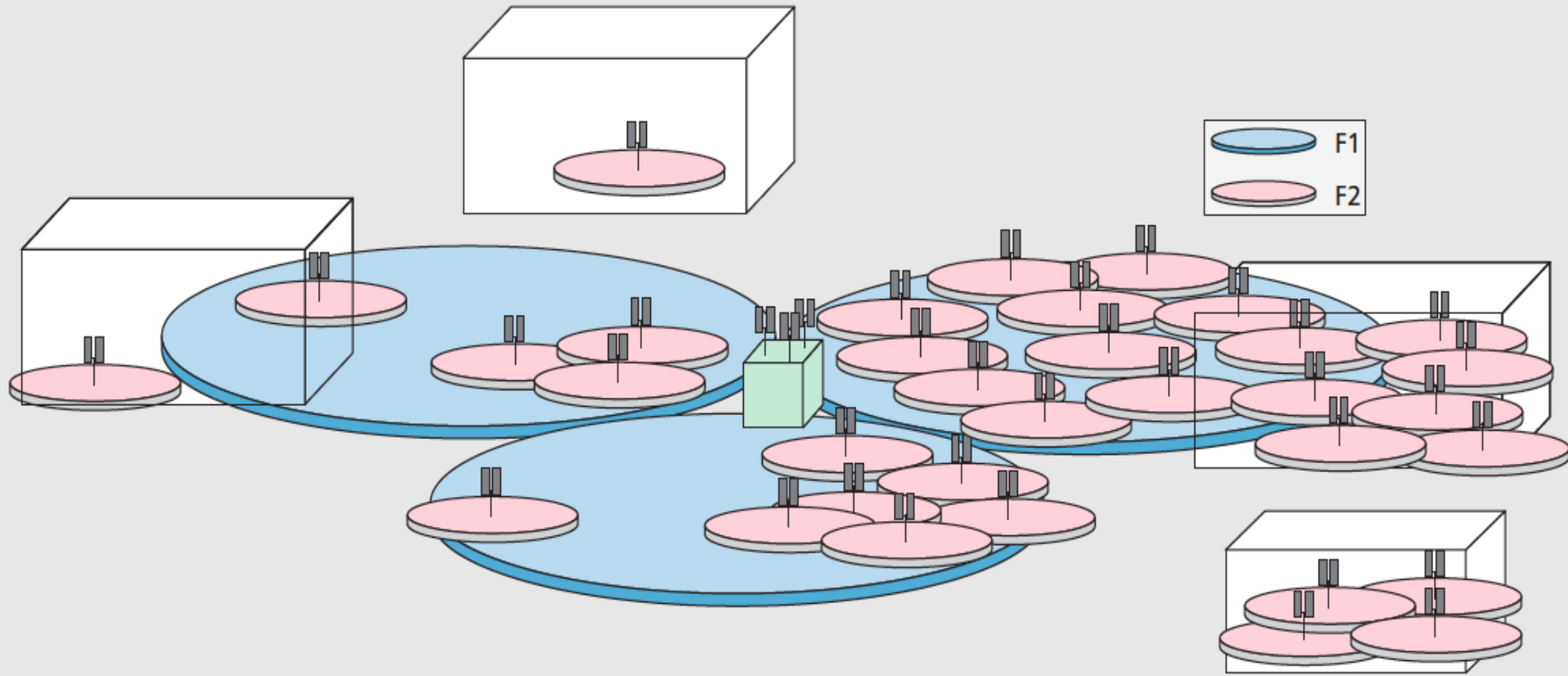
- 2007
- 16 technology companies (Alcatel-Lucent, AT-T, Cisco, Ericsson, Nokia, Vodafone, ..)
- <http://www.smallcellforum.org/>



SMALL CELL FORUM

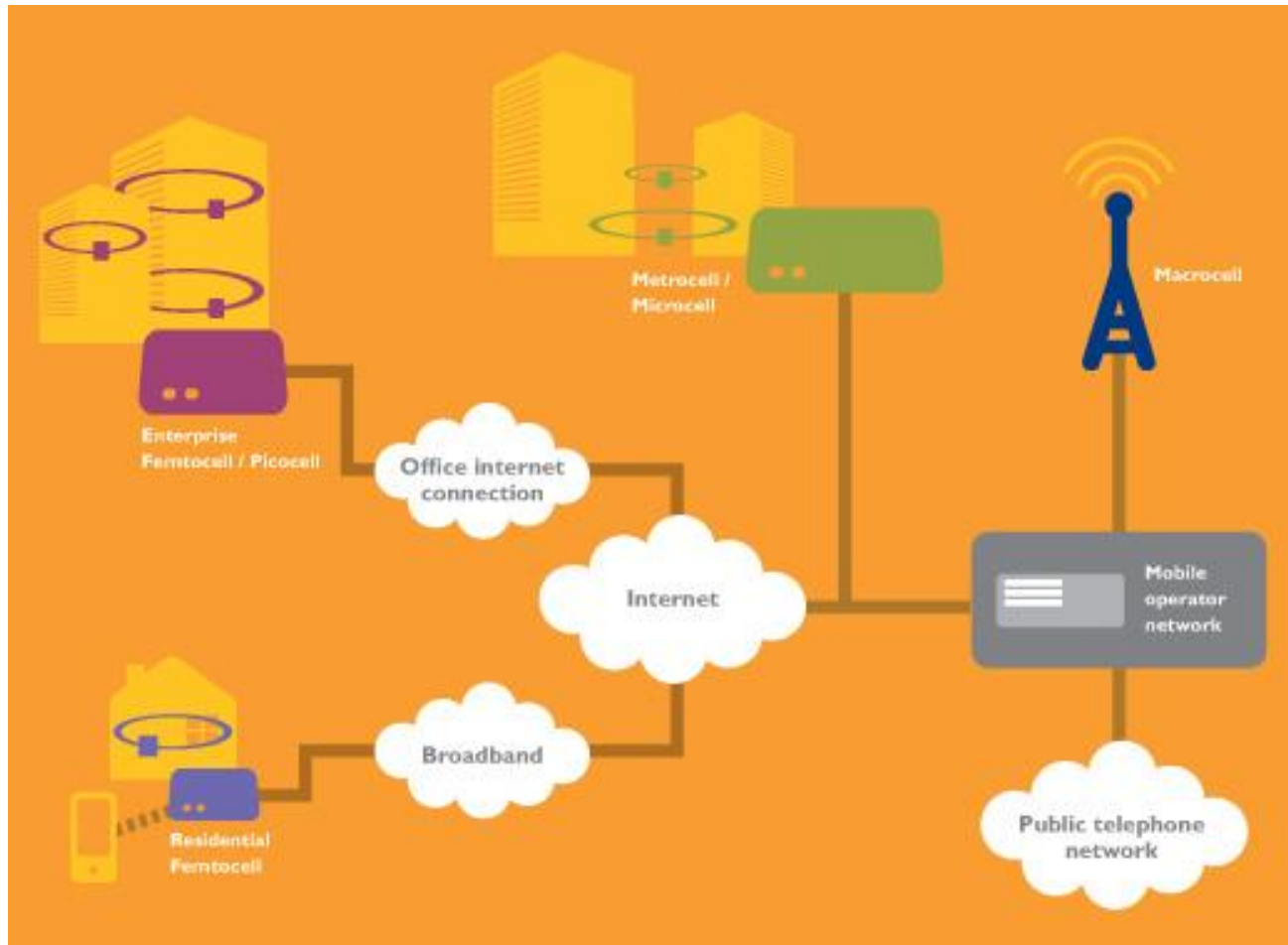
HOME | ENTERPRISE | URBAN | RURAL

Outdoor Deployment-1

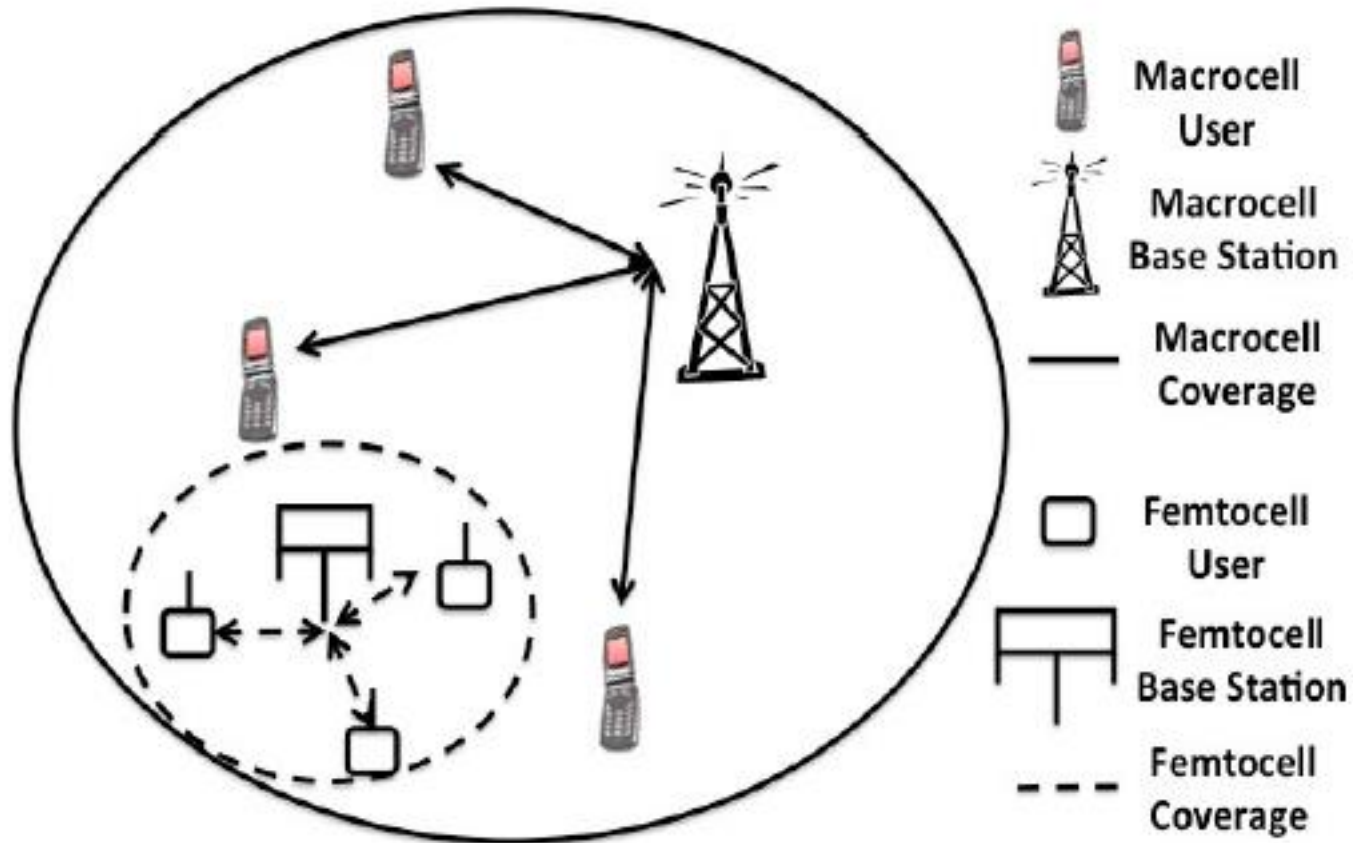


T.Nakamura et al., "Trends in Small Cell Enhancements in LTE Advanced", IEEE Communications Magazine, Feb.2013.

Outdoor Deployment-2



Indoor Deployment-1



Indoor Deployment-2

