



UNIK4230: Mobile Communications

Spring 2013

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Small cells and HetNet

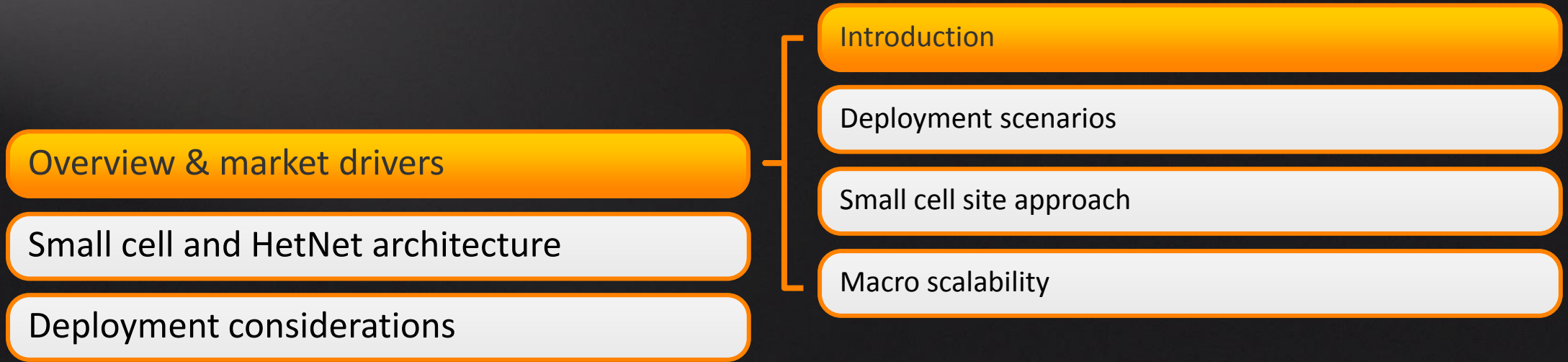
25.04.2013

Materials contribution: Nokia Siemens Networks

for a
world
in motion™

Small cells

Contents



Drivers for small cells

Coverage

Improve indoor coverage



Fill coverage gaps & holes



Fill new coverage areas



Enterprise solutions



New services



Fixed mobile convergence



New opportunities

Capacity

Macro not feasible



Dense hotzone capacity



Offload from macro



Tools to manage network evolution with lower TCO

Maximize macro usage



6-sector



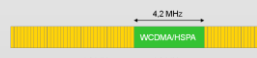
Active antenna



Baseband pooling



Spectral efficiency



Re-farming



New radio technologies

Utilize traffic management solutions



Caching



Content optimization



QoS & DPI



Network mgmt automation & SON

Deploy small cells to complement macro



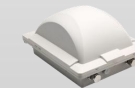
Micro



Pico



Femto



Wi-Fi



Offloading

Different small cell deployment scenarios

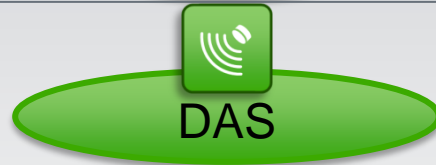
Indoor: 10-100mW
 Outdoor: 0.2-1W
 Coverage radius: 10s of meters



Indoor: 20-100mW
 Outdoor: 0.2-1W
 Coverage radius: 10s of meters



Indoor: >10W
 Outdoor: >10W



Indoor: 100-250mW
 Outdoor: 1-5W
 Coverage radius: 10s of meters



Outdoor: 5-10W
 Coverage radius: 100s of meters



Outdoor: >10W
 Coverage radius: kilometer(s)



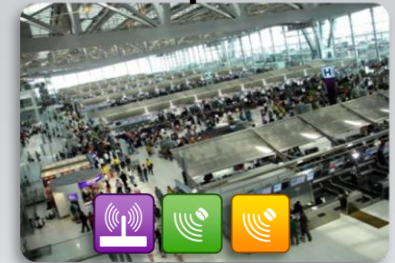
Home



Office



Airport



Shopping center



City walk



Stadium



City center



Suburban

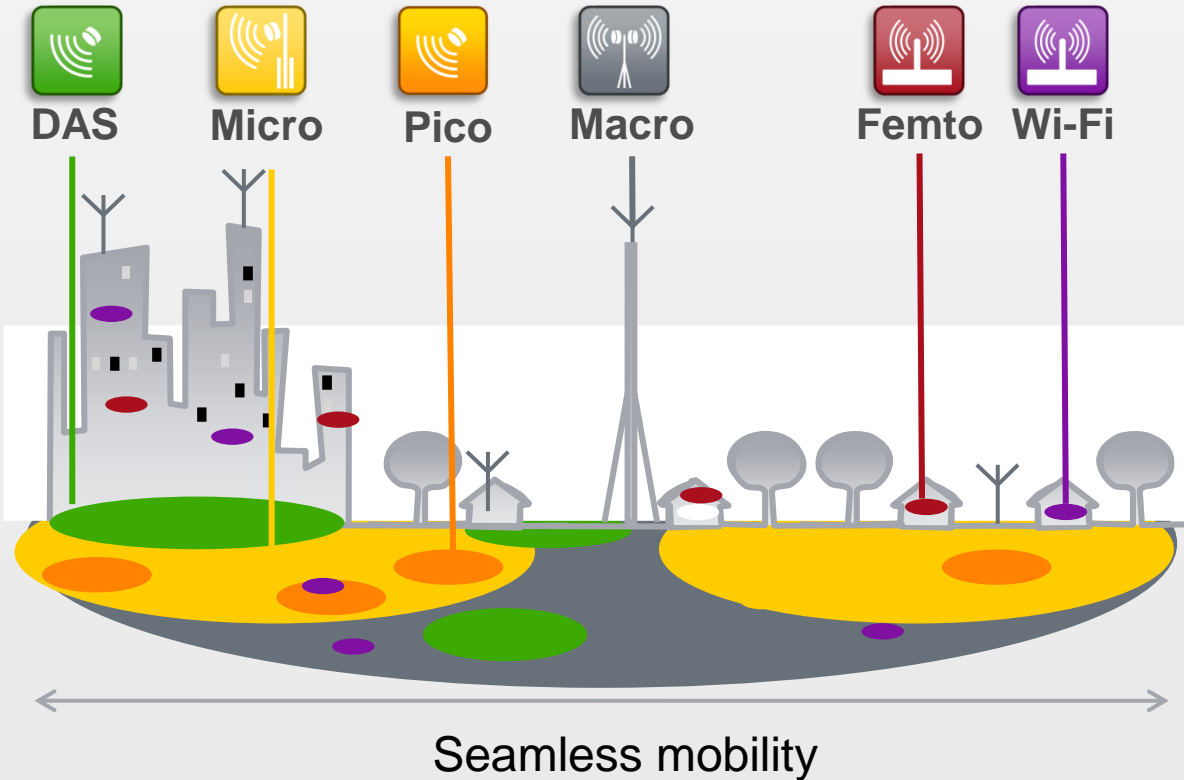


Village



Small cells and heterogeneous network

LTE – HSPA – GSM – WI-FI



Always best connected user experience

Seamless interworking between different cell sizes, frequency layers and radio technologies

Interference management

Layer optimization and traffic steering

Scalable smart network management and SON automation

Users expect always best connected experience

3G feature phones



Basic GSM phones



Smart phones



- Same services
- Plug and play
- Seamless mobility
- Secure
- Affordable or no cost

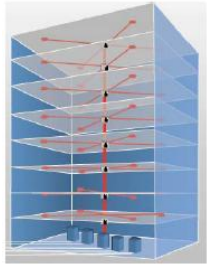
Laptops and tablets



Small cell solutions must support voice, SMS and access to Internet for all device types
Heavy multimedia usage on smart phones, laptops and tablets require high capacity mobile broadband

Maturity level of different small cell technologies

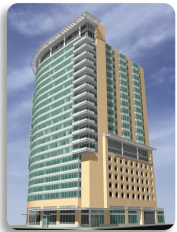
Mature mainstream -
Widely used globally



Indoor DAS



Outdoor DAS



Enterprise

Wi-Fi



Home

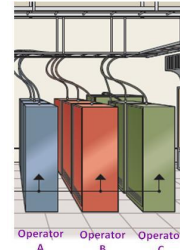


Public

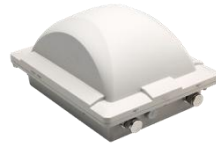
Emerging solutions



HSPA Femto



LTE DAS



Wi-Fi cellular
interworking

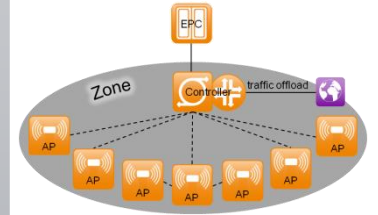


HSPA Micro

Future technologies



LTE Micro/Pico



LTE Pico cluster

Heterogeneous Networks



LTHE

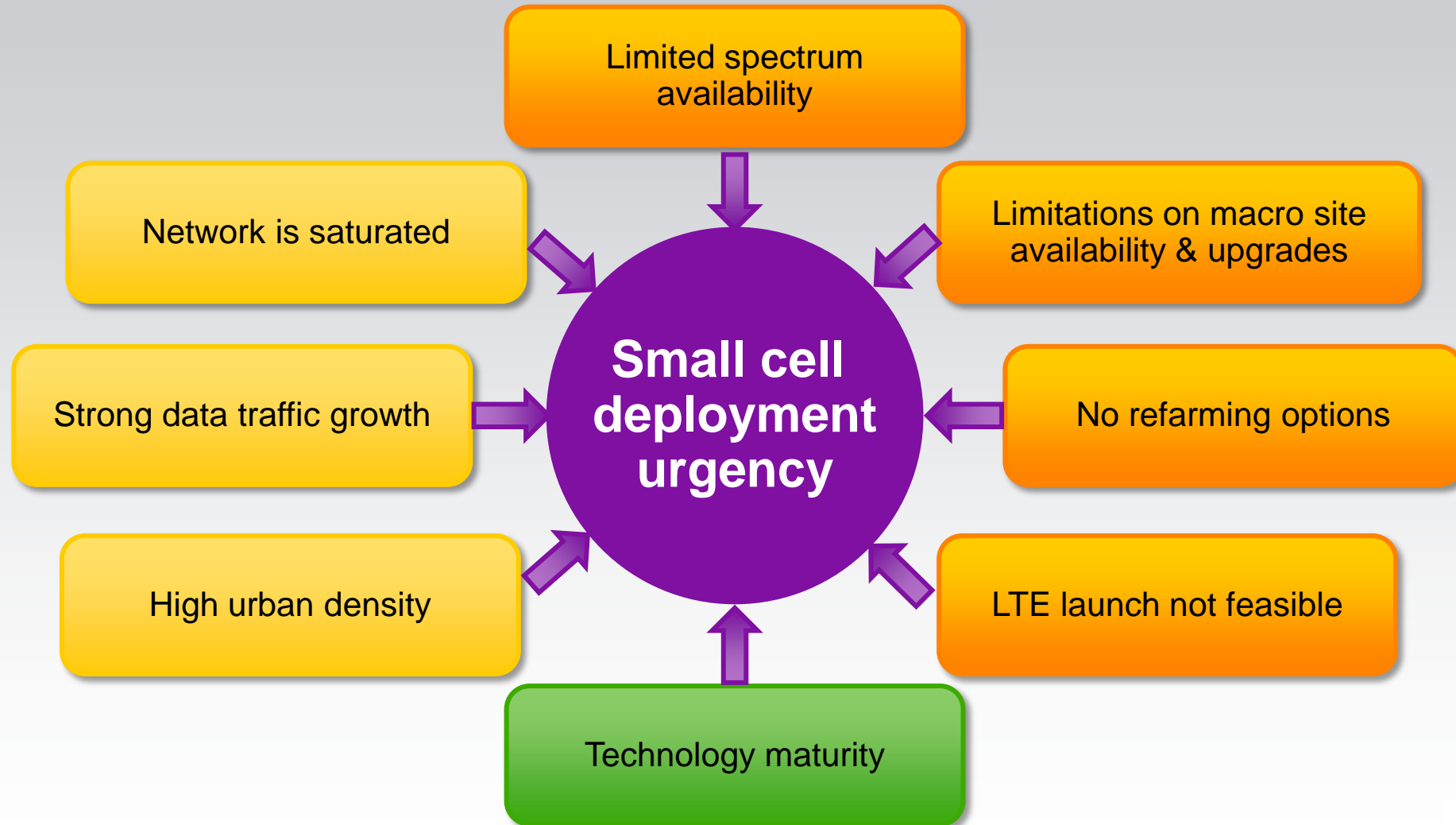


LTE-A











802.11ac

Factors impacting operator small cell deployment timing



Definitions of different small cell types

	Indoor			Outdoor				
								
	Wi-Fi	Femto	Pico	Wi-Fi	Femto	Pico	Micro	Macro
Output transmit power	20mW - 100mW	Residential 10 -100mW Enterprise 100-250mW	100mW - 250mW	200mW - 1W	200mW – 1W	1 - 5W	5 - 10W	>10W
Architecture	LAN	Gateway	Macro / Gateway	Gateway	Gateway	Macro / Gateway	Macro	Macro
Coverage radius	<50 meters	<50 meters	<100 meters	10s of meters	10s of meters	~100 meters	100s of meters	Kilometer(s)
Size and weight	<1L <1kg	<1L <1kg	2-4L 1-3kg	3-8L 2-5kg	3-8L 2-5kg	5-10L 5-10kg	10-50L 8-20kg	30-500L 30-200kg
Max users	20-30	8-16	16-64	30-150	8-32	16-64	64-256	>256
Typical deployments	Consumer Enterprise Cafe	Consumer	Enterprise	Lamp posts Building walls Utility poles	Lamp posts Building walls Utility poles	Lamp posts Building walls Utility poles	Lamp posts Building walls Utility poles	Tower masts Rooftops

Small cells

Contents

Overview & market drivers

Small cell and HetNet architecture

Deployment considerations

Introduction

Deployment scenarios

Small cell site approach

Macro scalability

Small cell deployment example: City center

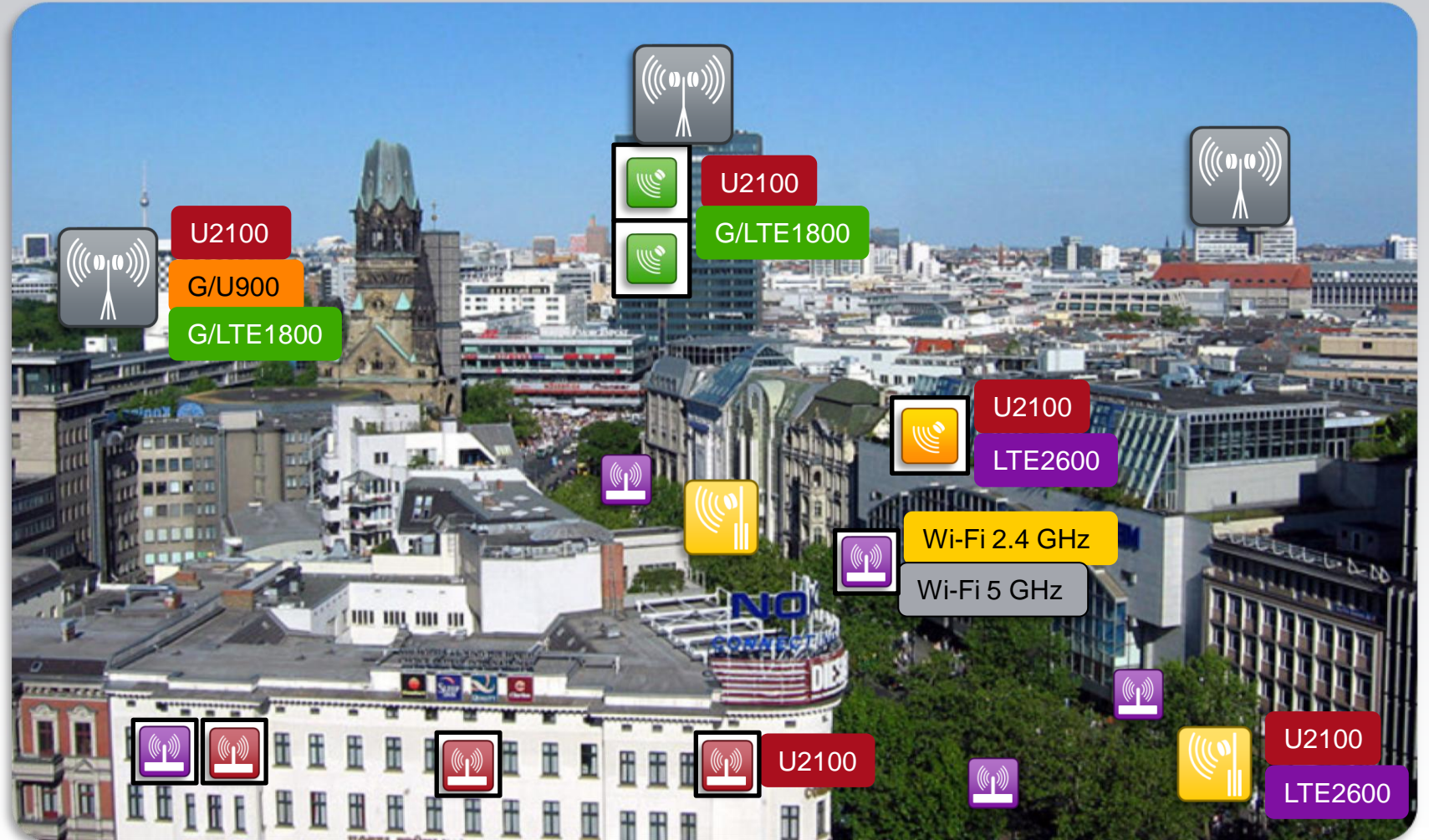
Example EMEA frequency use scenario

indoor

-  Public Wi-Fi
-  Femto
(10-100 mW)
-  Pico
(0,1 – 1 W)
-  DAS
(macro)

outdoor

-  Public Wi-Fi
-  Pico/Micro
(1 – 10 W)
-  Macro
(> 10 W)



Small cell deployment alternatives: City walk

Multiple options for different use cases



Outdoor DAS

- All devices, CS+PS services
- Can be shared with other operators
- Part of macro network



Outdoor pico/micro

- All devices, CS+PS services
- Typically operator specific
- Offload traffic from macro network
- Can be combined with outdoor Wi-Fi



Outdoor Wi-Fi

- Broadband connection for laptops, tablets and smartphones
- Offload data from cellular network



Small cell deployment alternatives: Stadium

Need for dense capacity



Outdoor DAS

- Can be shared with other operators
- Part of macro network
- Additional capacity using carrier Wi-Fi



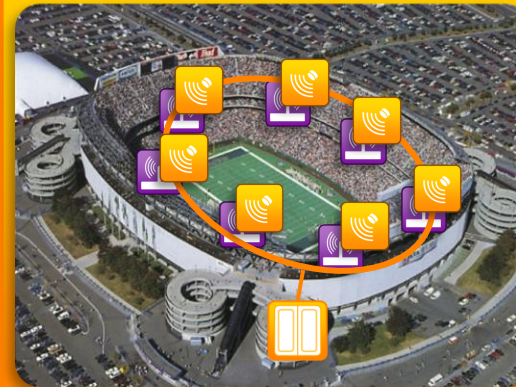
Remote radio heads

- Typically operator specific
- Fiber fronthaul to centralized baseband
- Part of macro network topology
- Additional capacity using carrier Wi-Fi



Micro/pico cells

- Typically operator specific
- Part of macro network topology
- Additional capacity using carrier Wi-Fi



Pico cluster

- Typically operator specific
- Local cluster network topology
- Carrier Wi-Fi can be co-located with pico BTSs

Small cell deployment example: Suburban

Femto coverage & offloading, private Wi-Fi for fixed BB extension

indoor



Private Wi-Fi

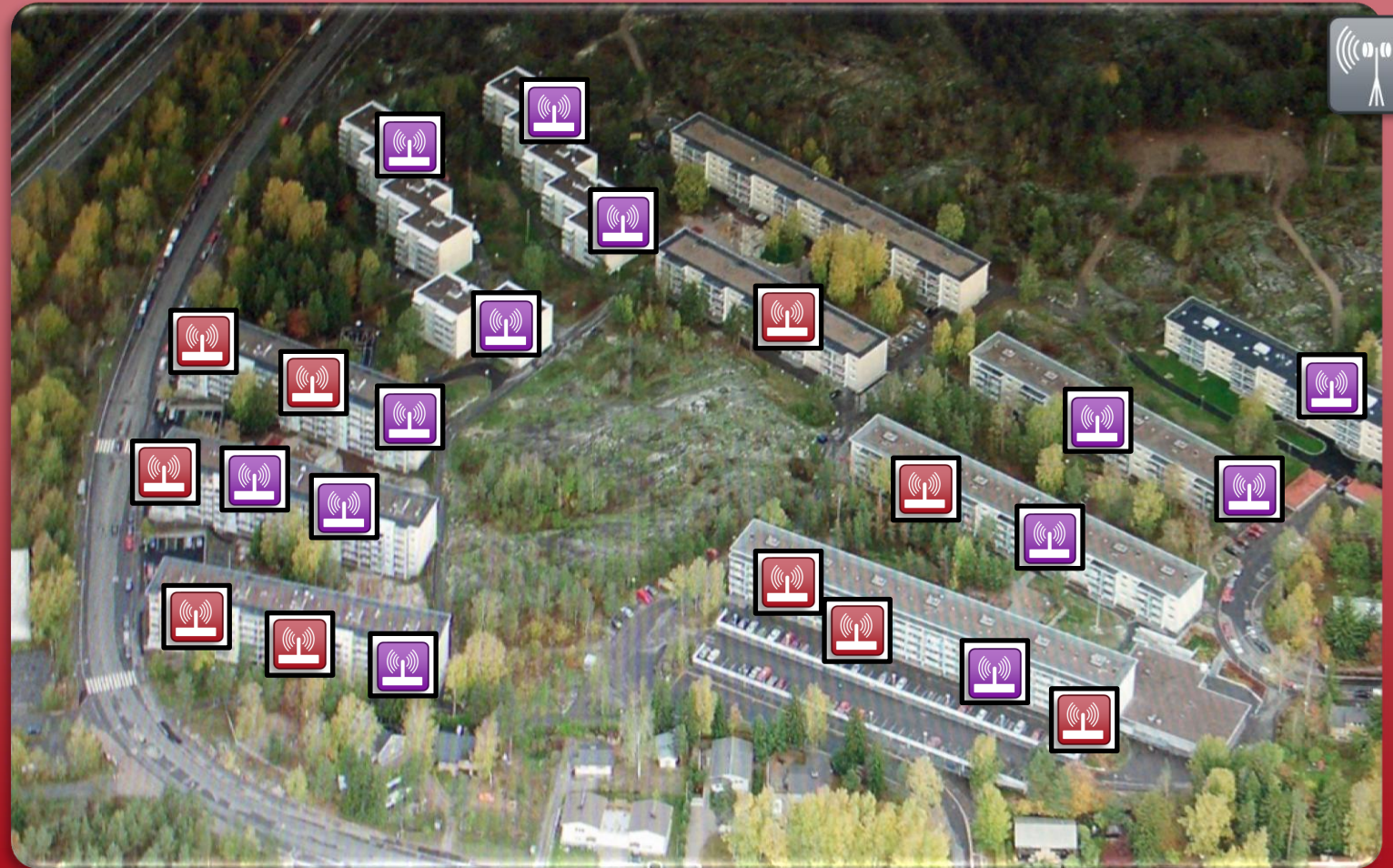


Femto
(10-100 mW)

outdoor



Macro
(> 10 W)



Small cell deployment examples: Village

Missing mobile coverage and no permission for macro site

outdoor



Micro
(5 – 10 W)

- Permission and site easier to acquire
- Lower total cost of ownership
- Reduced coverage unless many micros are deployed



Small cell deployment alternatives: Residential home

Fixed access availability determines alternatives



Fixed access is the main broadband connection

- Macro provides cell coverage for indoor & outdoor
- Wi-Fi for sharing fixed broadband for computers, smartphones and connected devices
- Femto for voice & broadband for cellular devices

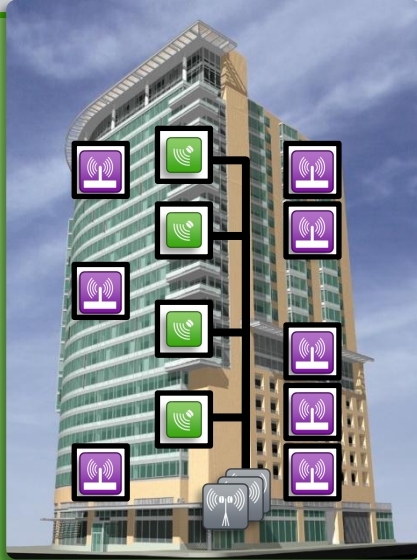


Cellular access is the only broadband connection

- Macro provides cell coverage for indoor & outdoor
- Additional coverage & capacity with nearby micro/pico
- Mobile router for sharing cellular connectivity for Wi-Fi capable devices

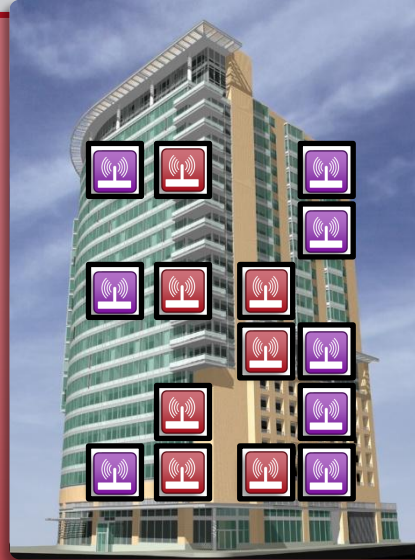
Small cell deployment alternatives: High rise building

Small cells for indoor coverage and capacity



In building DAS

- Initiated by real estate
- Typically multi-operator
- Open to all subscribers
- Utilizes macro base stations
- Planned interworking with macro
- Backhaul from building telco-room



Femto

- Planned and deployed by customer
- Dedicated to customer or open to all
- Utilizes femto gateway architecture
- Utilizes building LAN for backhaul



Pico

- Initiated by operator
- Open to all subscribers
- Part of macro architecture
- Planned interworking with macro
- Utilizes building cabling for backhaul

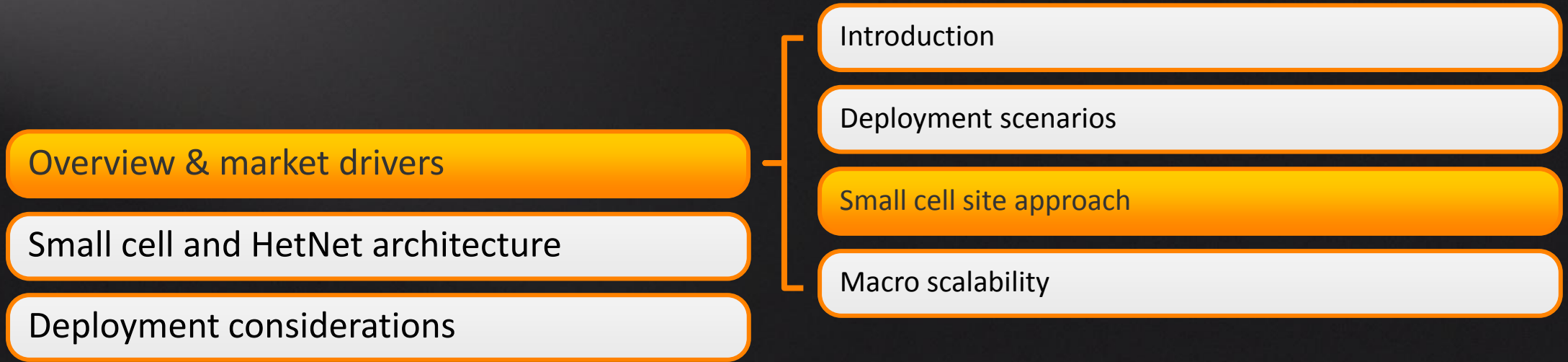


Customer deployed private Wi-Fi and optional guest Wi-Fi



Small cells

Contents



When might a new macro site not be feasible?



- No space for new macro site BTS or antennas.
- New macro site permits not granted or site lease is very expensive
- Site is too far from optimal location



- Cellular tower or pole is not accepted by authority community
- New macro site is overkill



- Macro sites cells capacity is not enough
- More and smaller capacity cells need to be added



- Safety regulations limit the transmitted power at street level



- Smaller cell and low transmit power is optimized for e.g. indoor usage, tunnels and parking lots



- New macro site is overkill (cost, capacity, size) for coverage fix or extension

Small cell site examples

Small cell site examples



Indoor enterprises



Indoor public spaces



Utility poles



Lamp posts



Residential homes



Outdoor building walls & rooftops



Strands

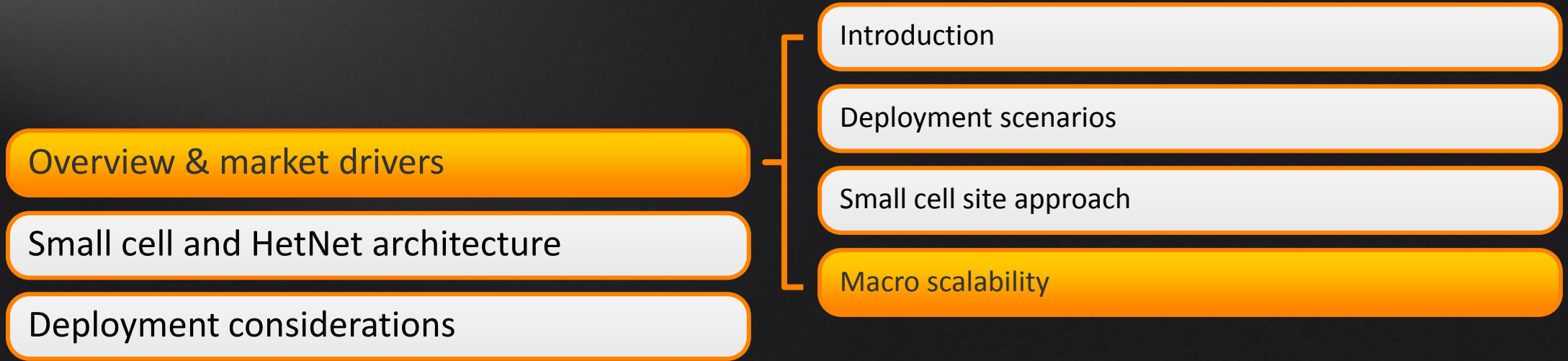


Bus stops

Key small cell cost items are site and backhaul

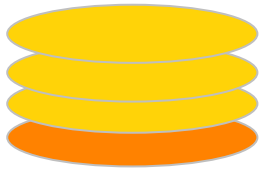
Small cells

Contents



Example European operator single macro site capacity limits

High capacity HSPA macro site

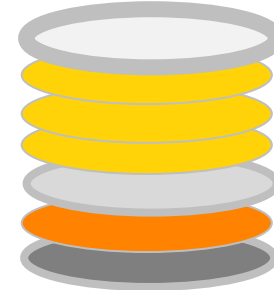


- 15 Mhz @ 2100 MHz band
- 5 MHz @ 900 MHz band
- **Total 4 HSPA carriers**



- Average HSPA cell throughput 6 Mbps
- 3 sector site with 72 Mbps throughput
- 6-sector site with 50% gain provides 108 Mbps (up to 80% gain possible)
- Additional 20 - 30% gain with DC/MIMO

High capacity HSPA+LTE macro site



- LTE 20 MHz @ 2600 MHz band
- HSPA 15 Mhz @ 2100 MHz band
- LTE 10 MHz @ 1800 MHz band
- HSPA 5 MHz @ 900 MHz band
- LTE 10 MHz @ 800 MHz band
- **Total 4 carriers HSPA + 40Mhz FDD LTE spectrum**



- Average LTE cell throughput 35 Mbps (20 MHz)
- 3 sector site with 282 Mbps throughput
- 6-sector site with 50% gain provides 423 Mbps (up to 80% gain possible)
- Additional 20 - 30% gain for HSPA with DC/MIMO

Radio capacity and coverage for growing online consumption

Additional carriers and new bands

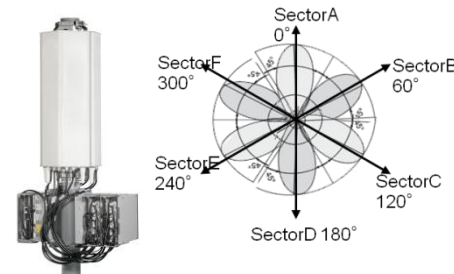
- Typical near future European operator scenario for MBB spectrum usage

2600 MHz	LTE 20 MHz
2100 MHz	HSPA 15 MHz
1800 MHz	GSM + LTE 10-20 MHz
900 MHz	GSM + HSPA 5 MHz
800 MHz	LTE 10 MHz

HSPA/LTE radio evolution improves spectral efficiency thus increasing capacity in cells

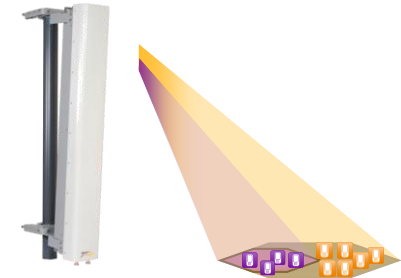
- HSPA+, LTE-A

Efficient macro sites



6-sector site

- up to 80% more capacity compared to 3 sectors
- up to 40% more coverage



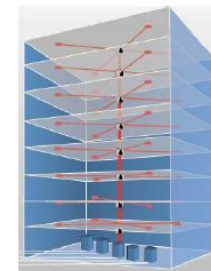
Active antenna

- up to 65% more capacity compared to standard sector
- up to 30% more coverage

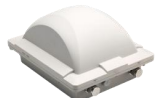
More capacity with small cells



Micro, pico



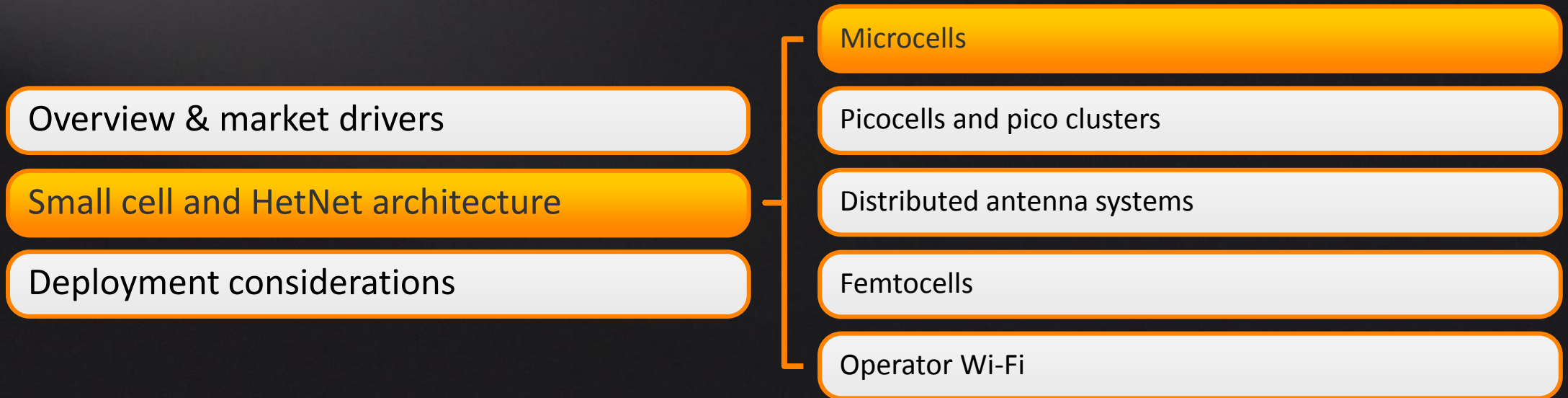
Femto



Carrier Wi-Fi

Small cells

Contents



What are micro base stations?

Base station

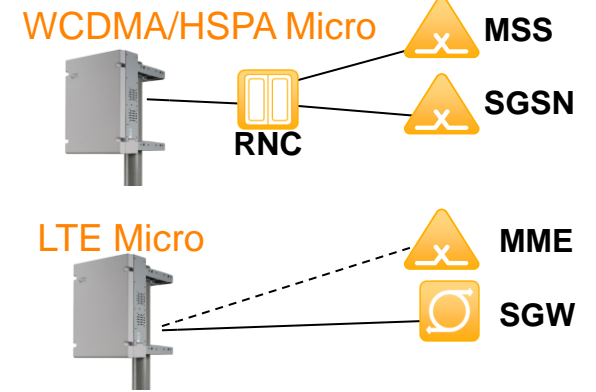


Site

Proposed 3g Bellbox Antennae Positions



Network



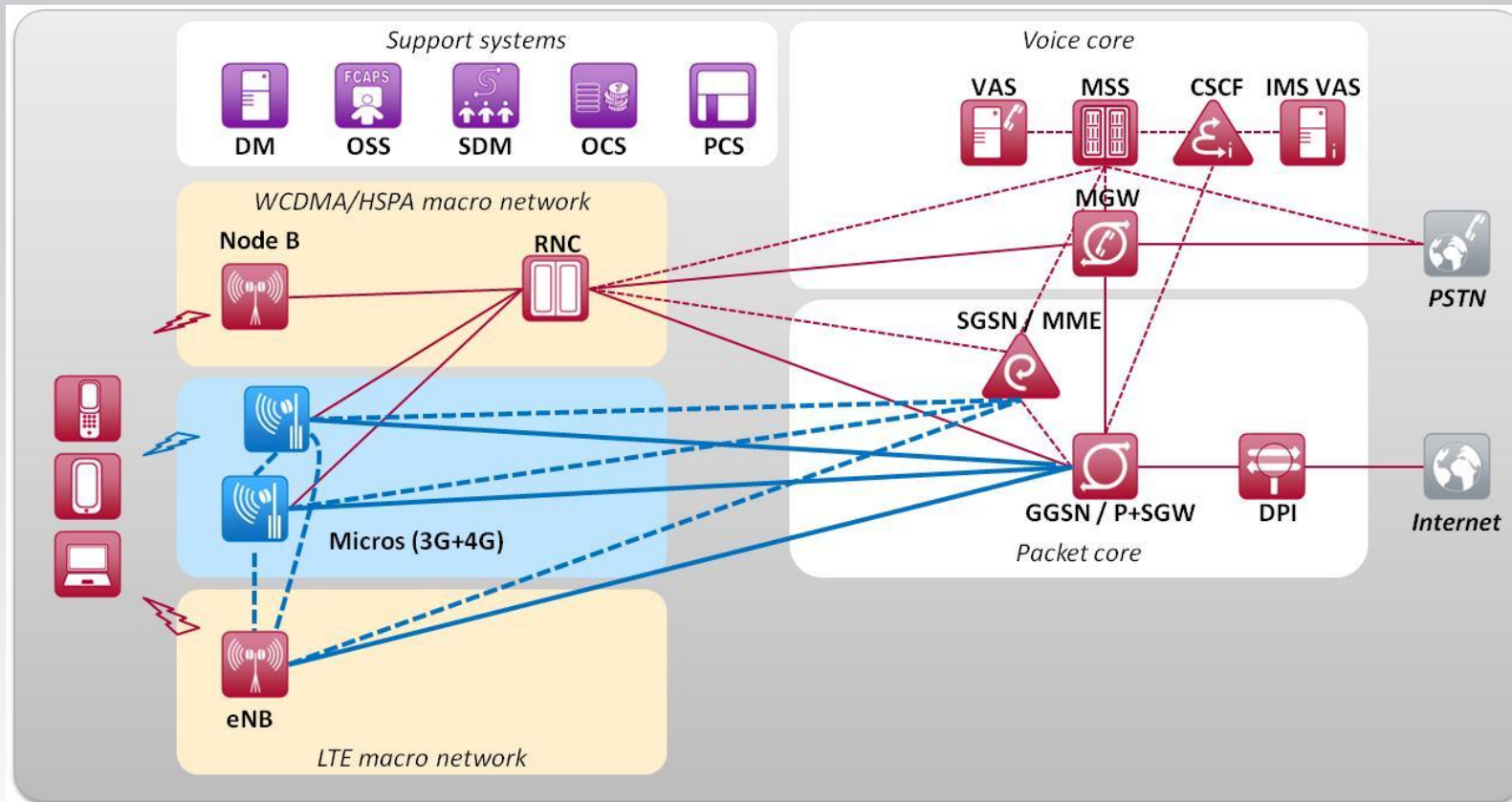
Outdoor

- Output power 1-10W, typically 5W
- Cell size typically 100s of meters
- BTS size 10 – 50L, expectations about 10L
- Small configurations, typically 1-2 cells/1 cell MIMO
- Typically 50-200 3G/4G users per BTS

- Deployment on wall, roof top and utility pole
- Small antennas typically quite close to users e.g. street level (short safety distance)
- Mainly outdoors, but possible also indoors e.g. airports, shopping malls and railway stations
- Medium BTS and site cost

- Utilize macro network topology
- Same features as macro cells
- Planned deployment & full mobility
- Dedicated or macro shared carrier
- For traffic hot spots or coverage fix
- Capacity & coverage when macro cell deployment is not feasible
- Fixed broadband and microwave backhaul

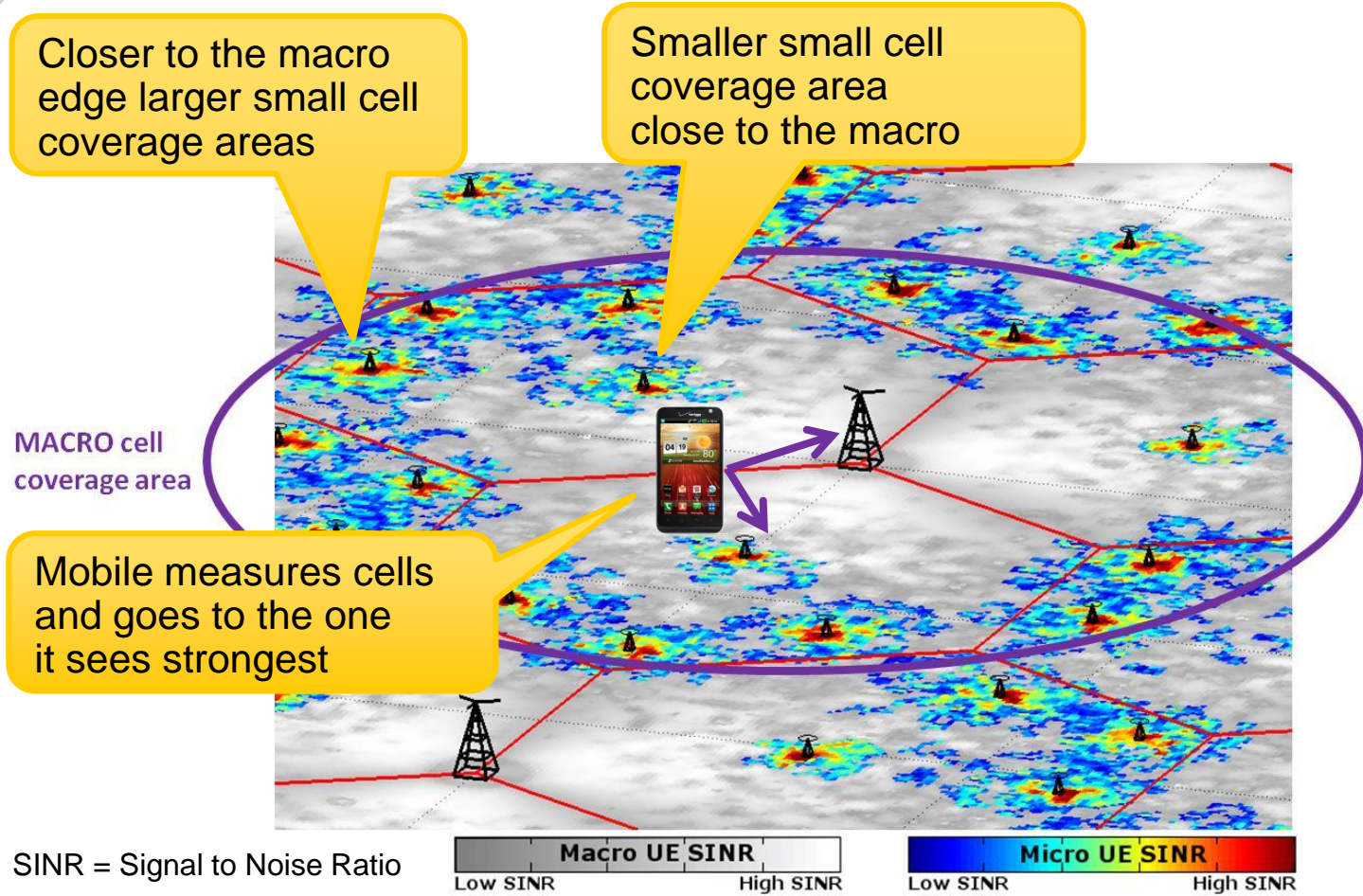
Micro uses common architecture with macro



WCDMA/HSPA: connected to RNC with same Iub-interface as macro Node B

LTE: connected to MME+SGW with same S1-interface as macro eNB.
X2 links needed between micro + surrounding macros/micros

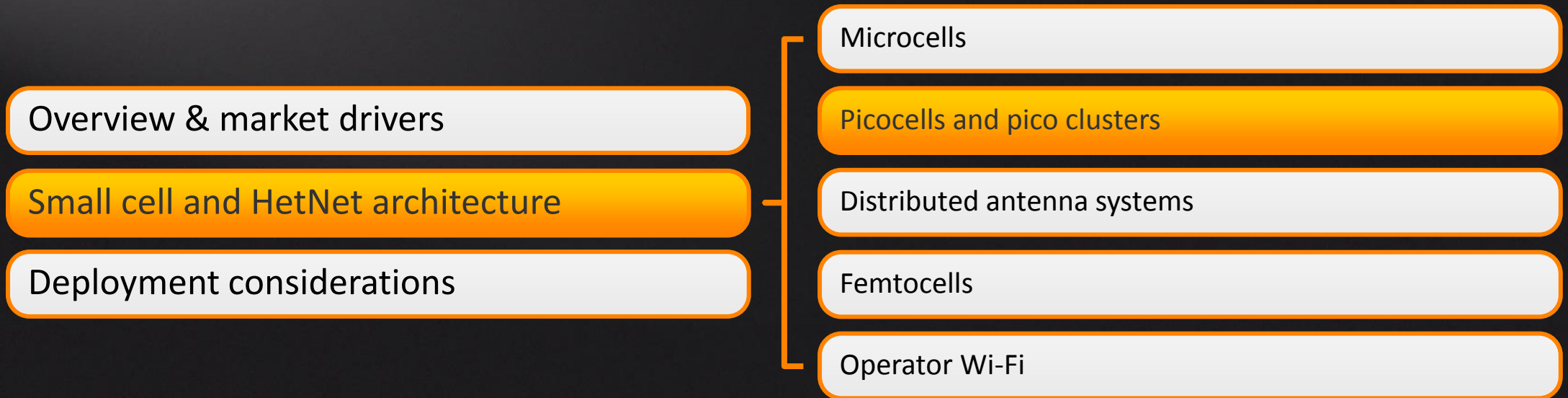
Learnings from a LIVE co-channel micro cell deployment



Macro-cell RSCP level [dBm]	On street co-channel 3G micro-cell radius [m]
-85	< 200
-75	100
-65	75
-55	< 50

Small cells

Contents

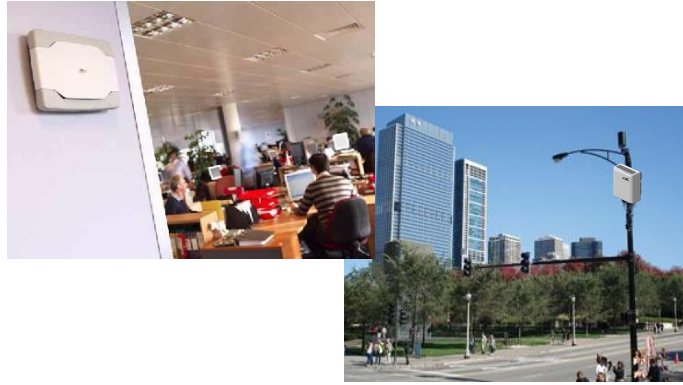


What are pico base stations?

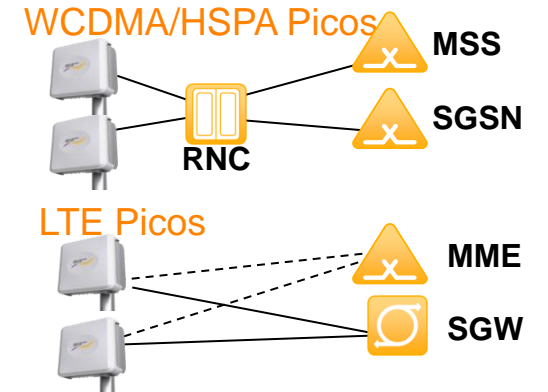
Base station



Site



Network



Indoor

- Output power 100-250 mW
- Size 2-4 L, 1-3 kg

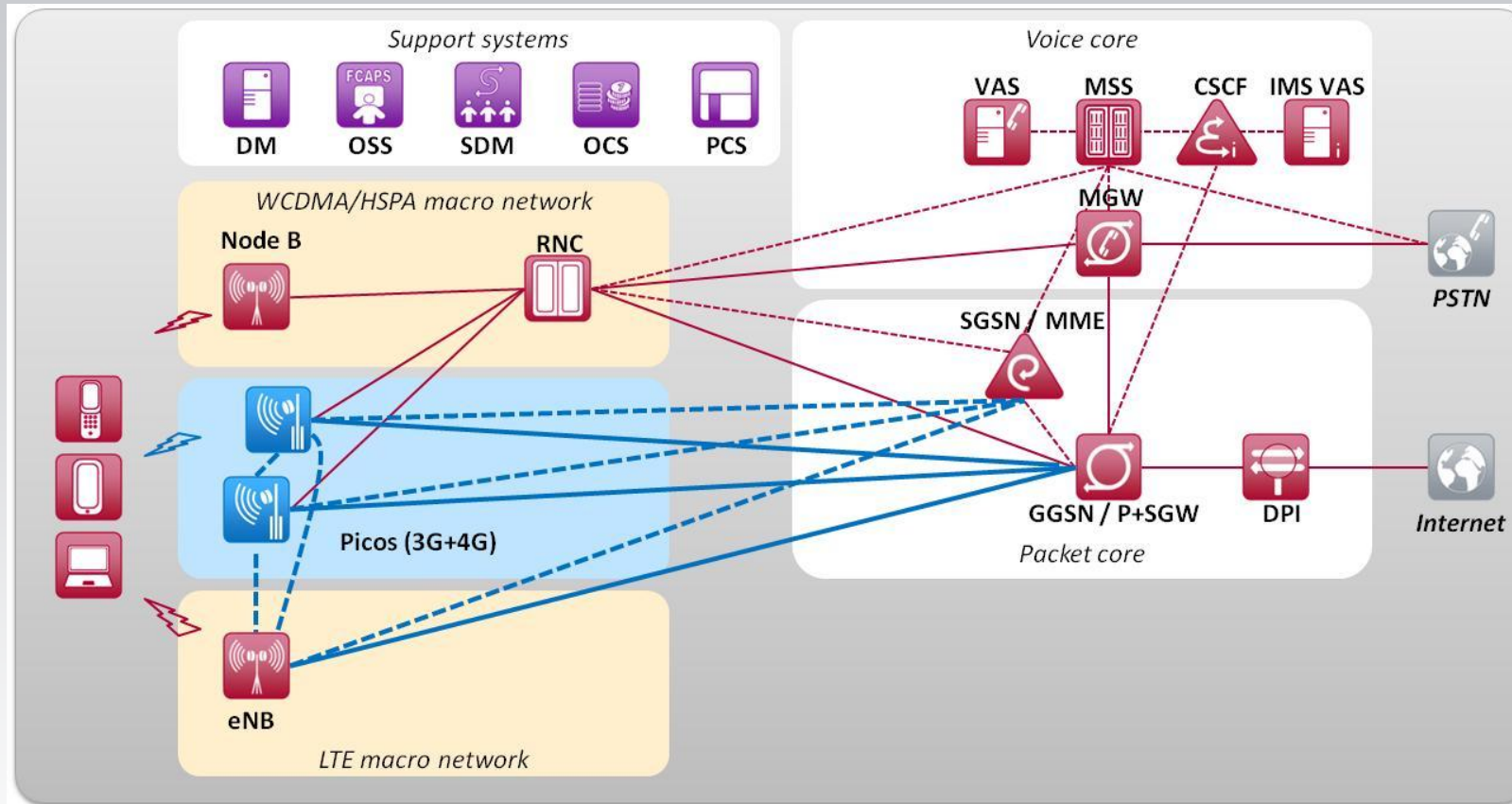
Outdoor

- Output power 1-5 W
- Coverage radius 10s of meters
- Size 5-10 L, 5-10 kg
- Integrated antenna
- Simultaneous users 16-64

- Indoor building visible location
- Outdoor lamp posts, building walls and utility poles
- Easy site acquisition and rental costs
- Requires low cost high speed backhaul transport solution
- Requires network planning, operator installation

- From network architecture perspective looks like macro cells
- Could be a subset of features and functionalities of macro cells
- Dedicated carrier (frequency) or same as for macro
- Indoor coverage/capacity or outdoor street level capacity solution

Traditional Pico architecture



WCDMA/HSPA: connected to RNC with same Iub-interface as macro Node B

LTE: connected to MME+SGW with same S1-interface as macro eNB.
X2 links needed between picos + surrounding macros/micros/picos

What are pico clusters?

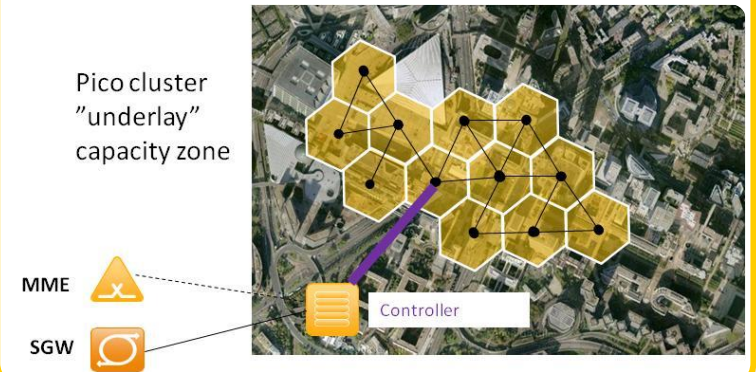
Base station



Site



Network



Indoor

- Output power 100-250mW
- Size 2-4 L, 1-3 kg

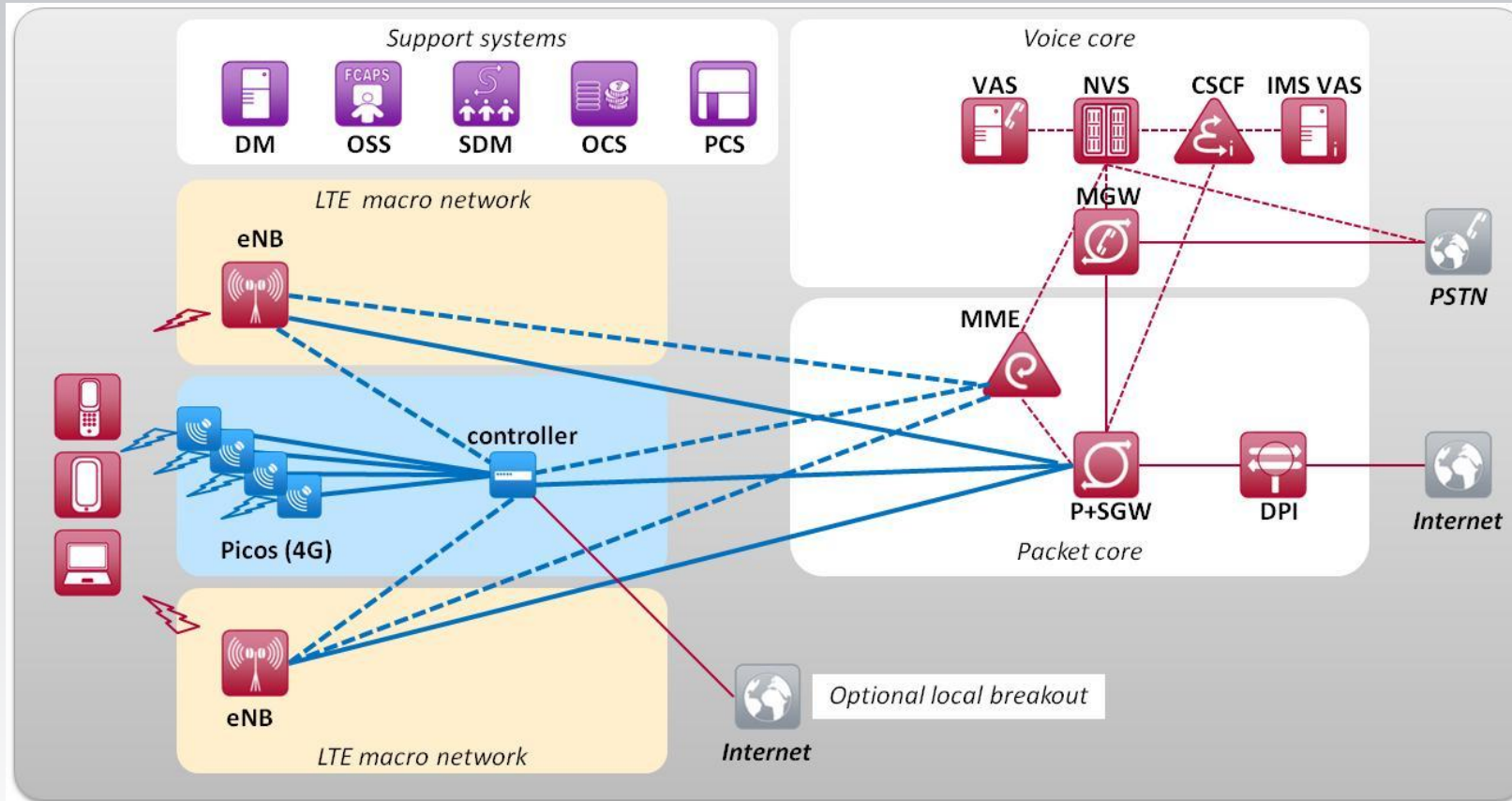
Outdoor

- Output power 1-5 W
- Coverage radius 10s of meters
- Size 5-10 L, 5-10 kg
- Integrated antenna
- Simultaneous users 16-64

- For areas where larger number of neighboring pico cells used to build outdoor "underlay" capacity zone or indoor small cell coverage/ capacity cluster
- Otherwise similar characteristics as with traditional pico sites

- Controller taking care of cluster internal signaling & mobility
- Dedicated carrier (frequency) or same as for macro
- Indoor coverage/capacity or outdoor street level capacity solution

Pico cluster architecture

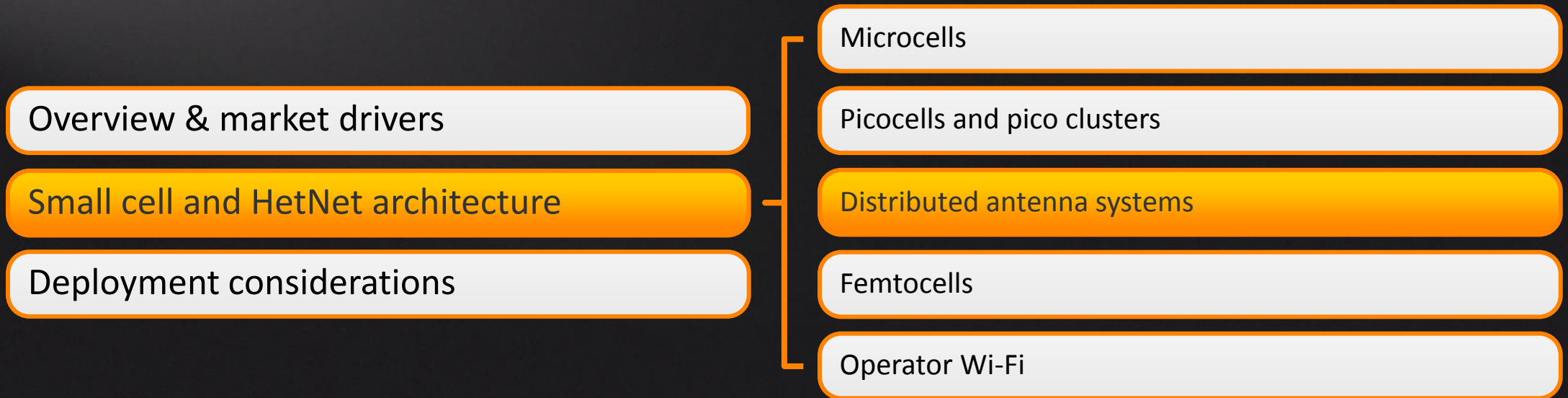


LTE:

The entire cluster looks like one S1 connection to MME+SGW. No X2 links needed between the nodes inside the cluster, towards surrounding macros X2 links from the controller.

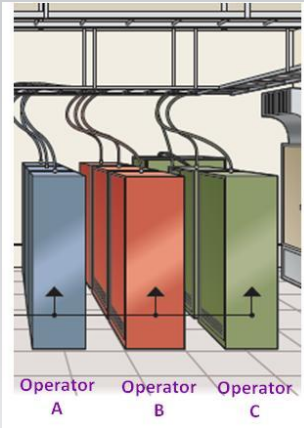
Small cells

Contents



What are distributed antenna systems (DAS) ?

Base station



Site

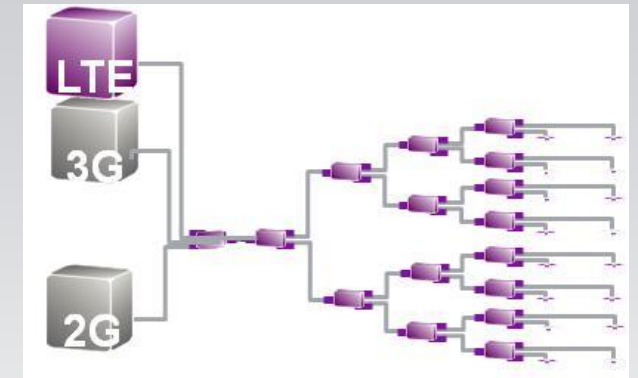


Indoor antenna



Outdoor antenna

Network



Macro BTS

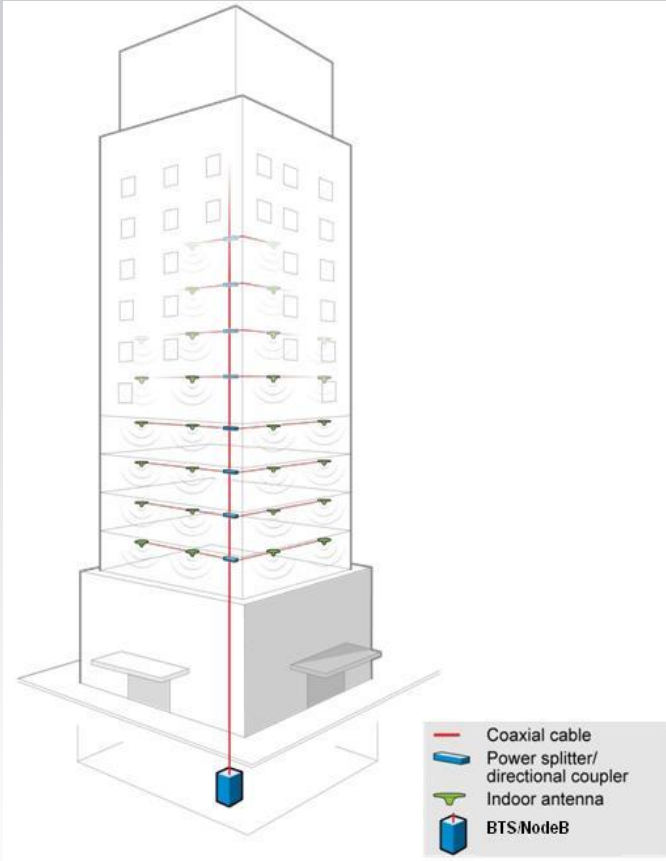
- Typically normal macro BTS connected to the DAS
- DAS can support sharing the antennas between multiple operators base stations

- Small indoor antennas in various building locations
- Outdoor lamp posts, building walls and utility poles
- Requires special DAS cabling in the buildings or outdoor area
- Requires network planning, operator installation

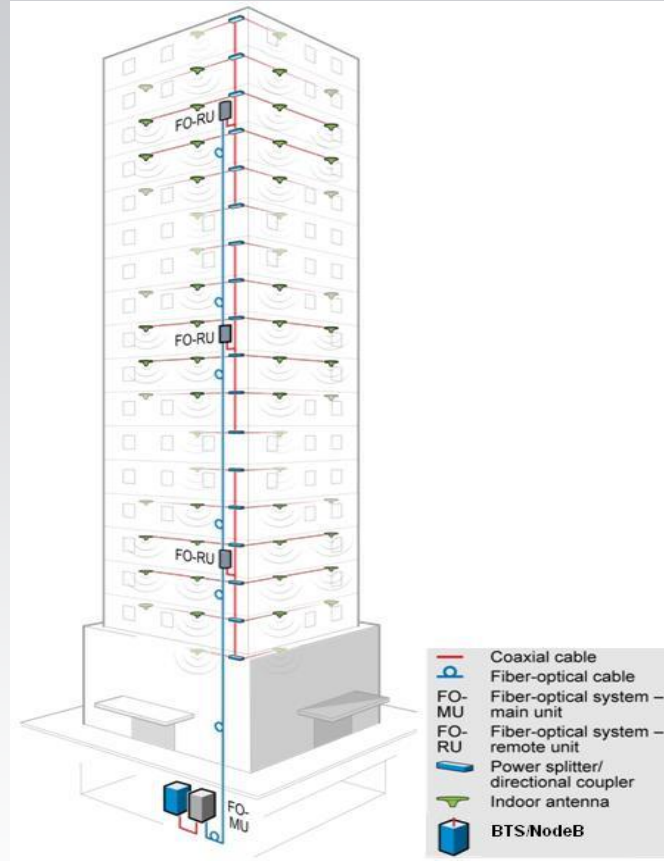
- From network architecture perspective looks like macro cells
- Macro features and functionalities
- Passive, active and hybrid options
- Shares carrier with macro
- Can be operated by 3rd party operator-independent companies
- Especially used as multi-operator indoor coverage solution



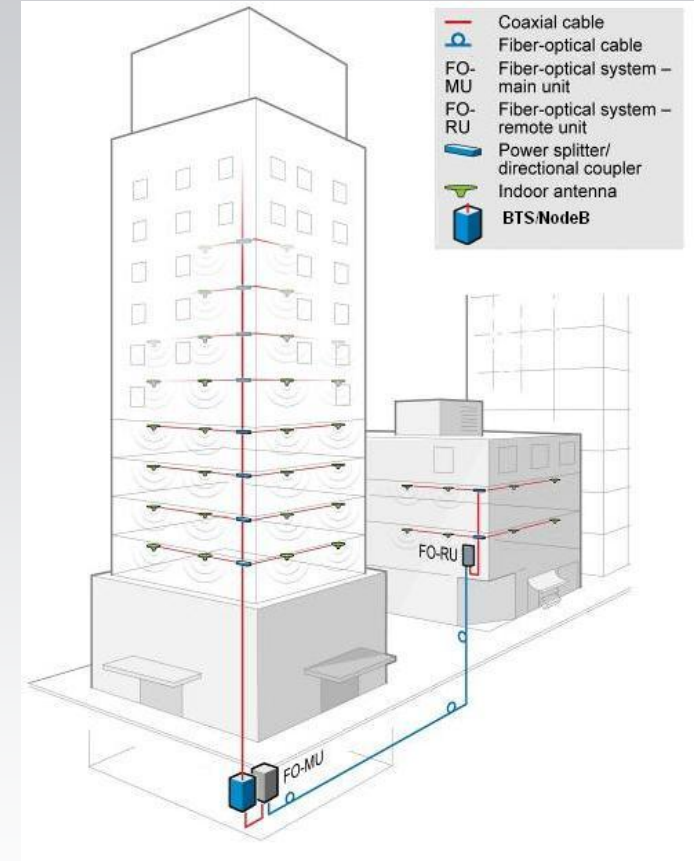
DAS Solution Examples



PASSIVE DAS

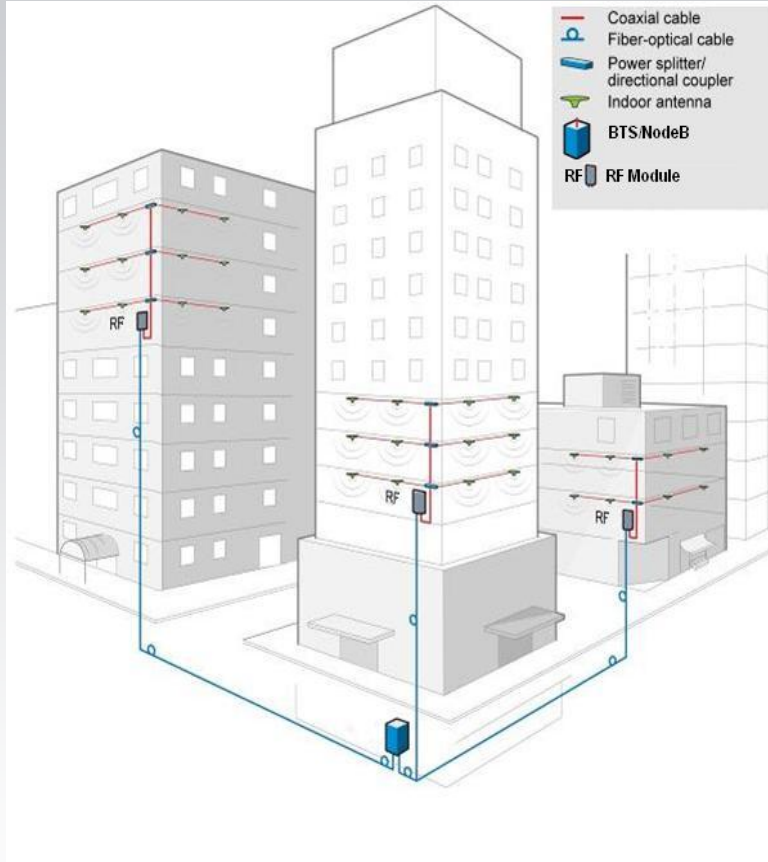


ACTIVE DAS

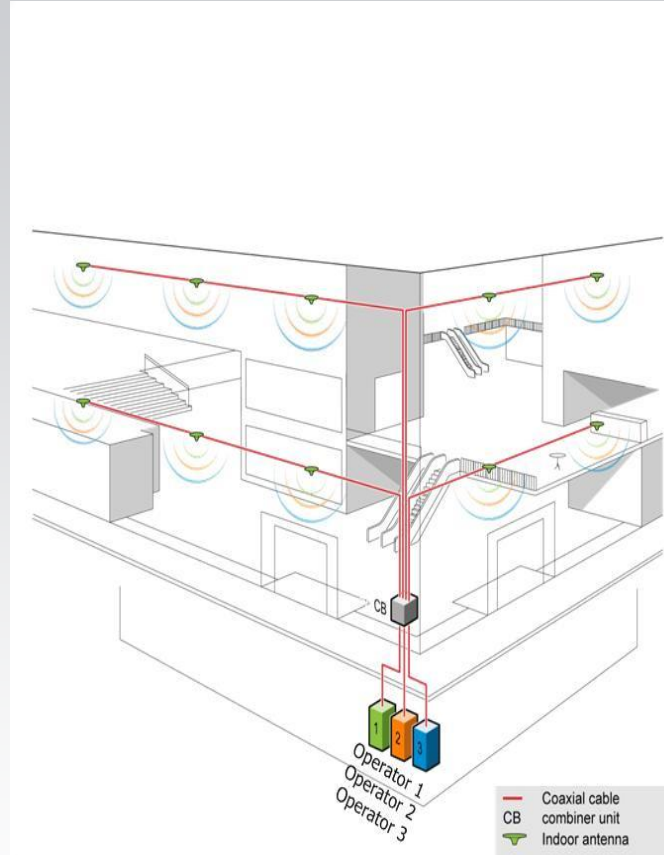


HYBRID DAS

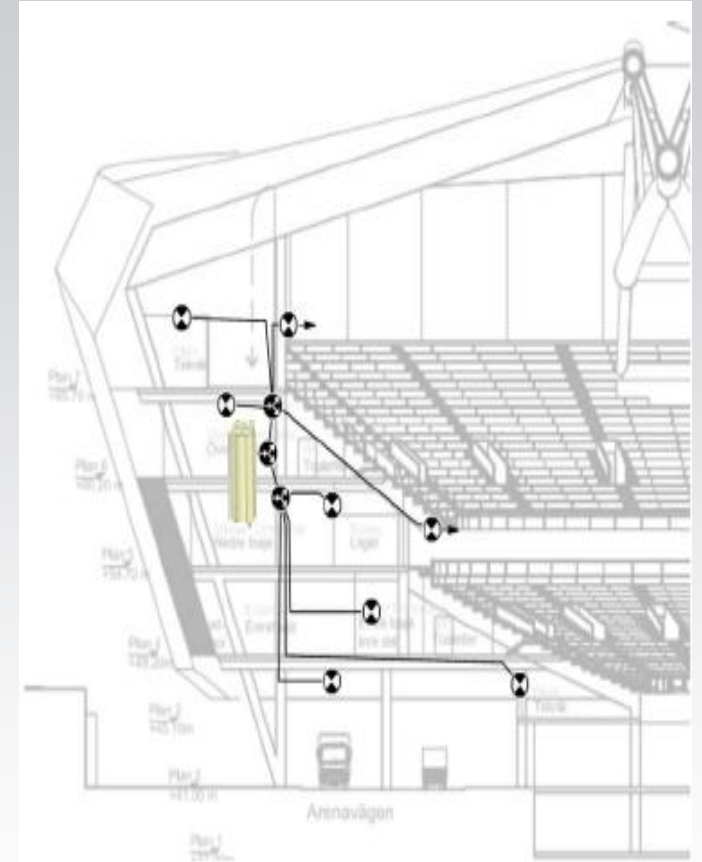
DAS Solution Examples



Distributed BTS



**Multi Operator –
Multi Technology DAS**



Outdoor DAS for Stadium

What are outdoor DAS systems ?

Outdoor DAS

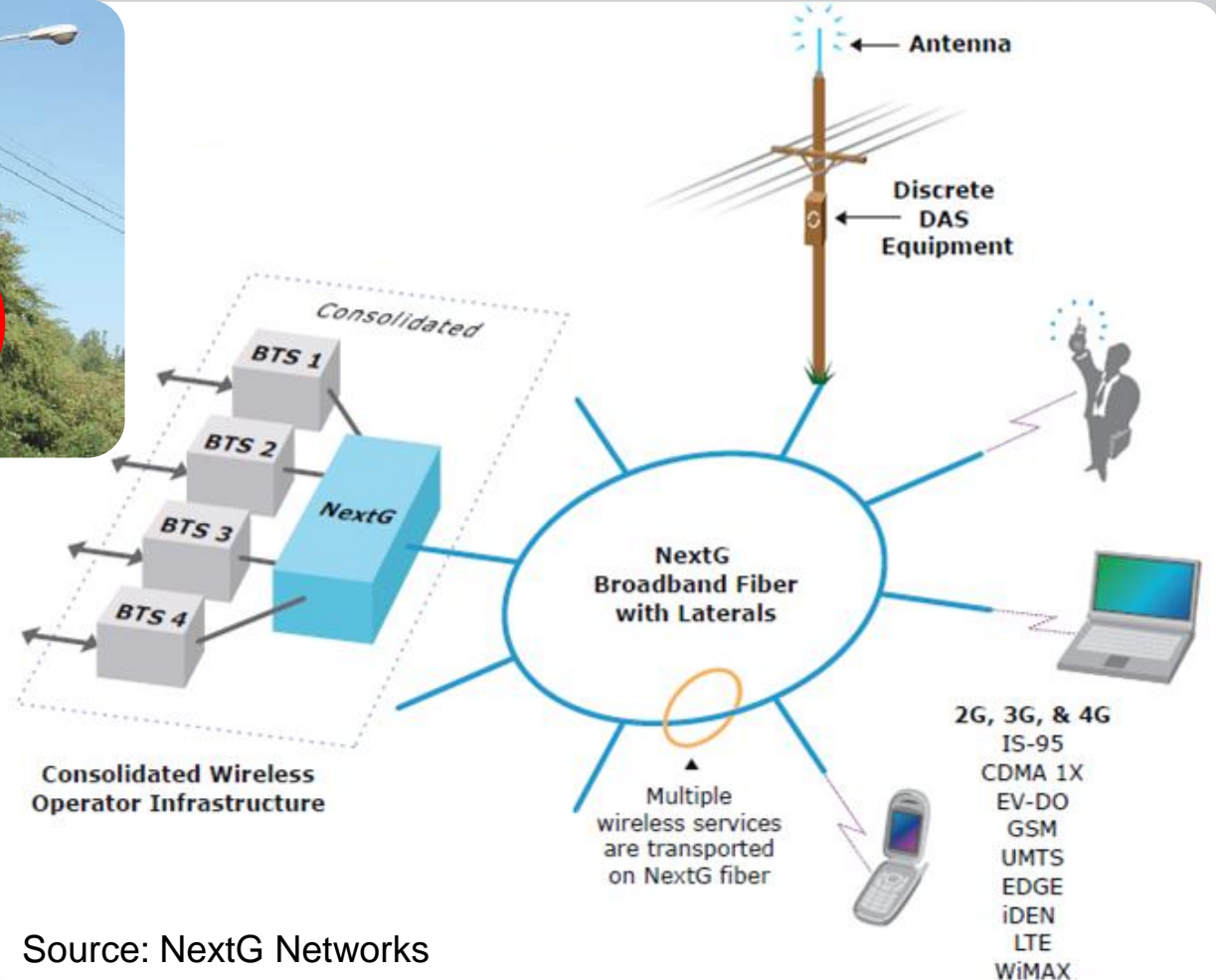
Capacity or coverage needs

Tough permitting environments

Densely populated areas



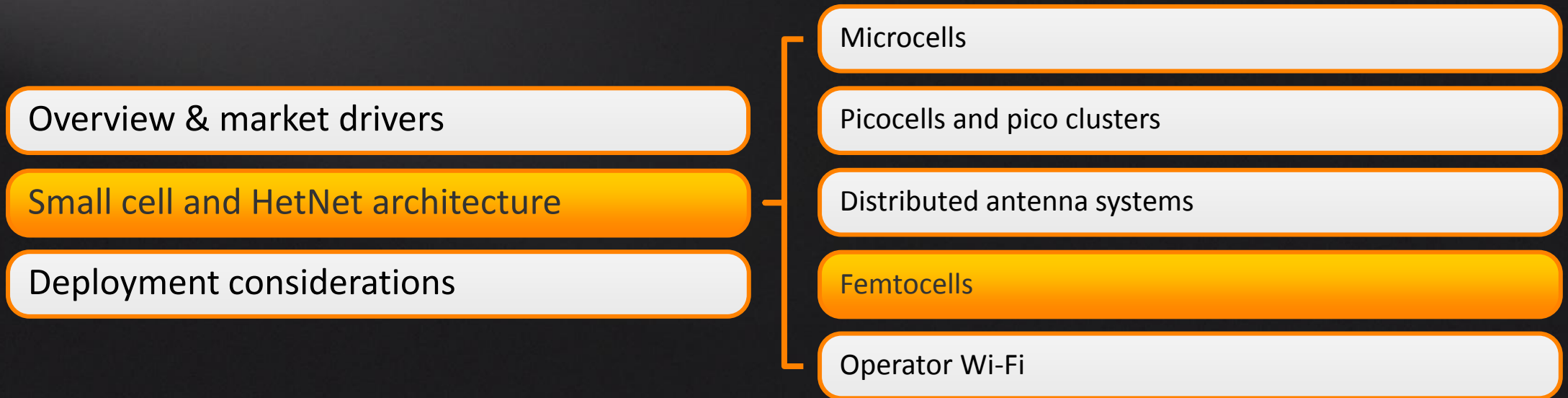
- Using lamp posts and similar infrastructure
- Typically run by dedicated companies that lease capacity to mobile operators
- Today used especially in big US cities



Source: NextG Networks

Small cells

Contents



What are femtocells?

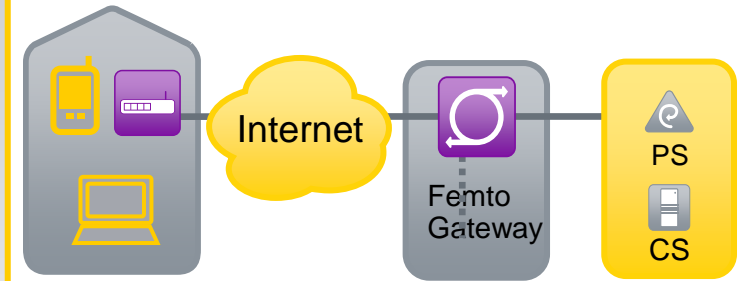
Base station



Site



Network



WCDMA/LTE femto

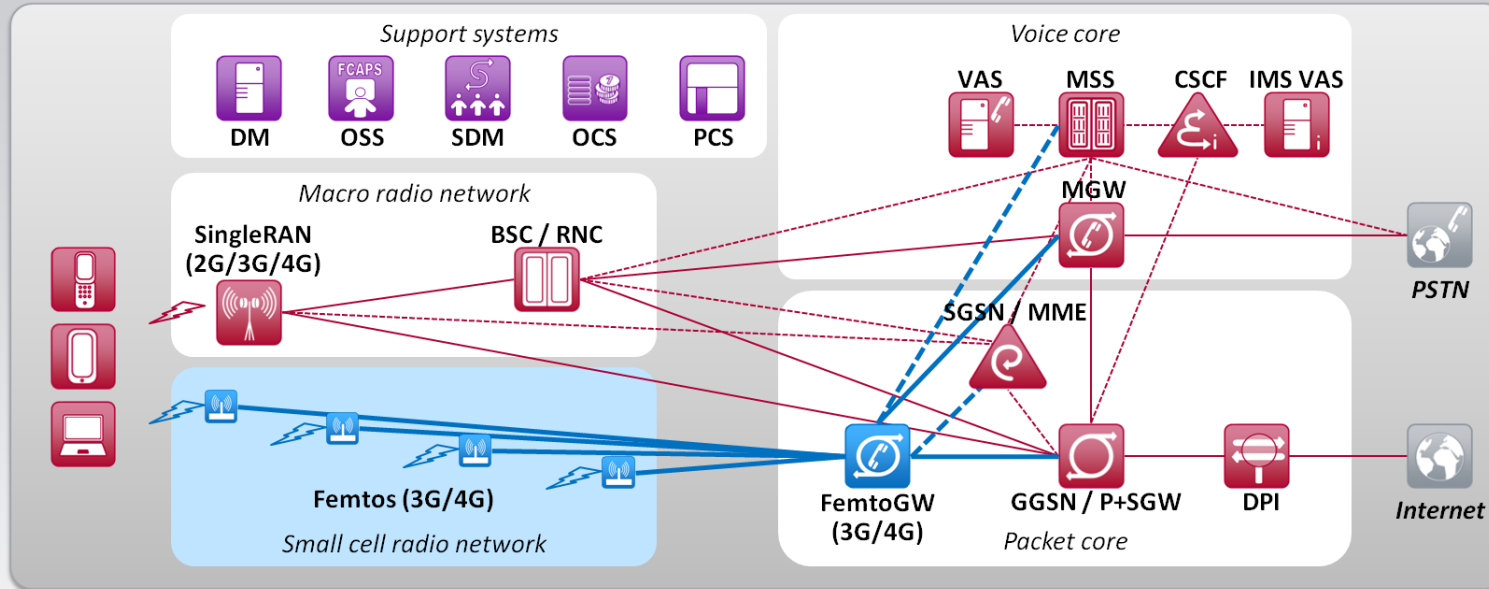
- Low cost very small HSPA/LTE base station for home or office
- Transmit power 10-100 mW *)
- Zero-touch installation, auto-configuration
- Open or closed access

*) can be higher, ~ 250 mW if operator-installed

- Indoor use: Home, SoHo, enterprise, office
- Single cell and multi-cell deployments

- Unplanned deployment
- Existing fixed broadband access used for backhaul
- Attaches to voice & packet core via femto gateway, optional local Internet offload (LIPA)
- 3GPP standardized interfaces (Iuh, S1, TR-69/196)

Femtocell architecture



WCDMA/HSPA: connected to core network with standard Iu-CS and Iu-PS interfaces via the femto GW. Femto access security and O&M also handled via the femto GW.

LTE: architecture still partly under discussion. Femto GW expected to be needed at least for security purposes.

Femtocell business drivers

Coverage enhancement

- Customer retention

Capacity boost

- Macro network offload

Femtocell-enabled value added services

- For example presence based applications



Today the most evident benefit of femtocells is to improve indoor coverage for voice and smartphones, especially where the operator does not have spectrum in low bands

Key femto deployment issues

Security

- Prevent tampering of FAP, transport security
- Solved by FAP hardening, IPSec transport, certificate based authentication

Interference mitigation and location locking

- Algorithms are in place, more advanced ones being developed

Mobility management

- UE capture by FAP, avoiding ping-pong with macro network

Cost of service provisioning and customer care

- Automated low-cost provisioning needed in mass deployments



Main femto deployment scenarios

Closed Residential SoHo

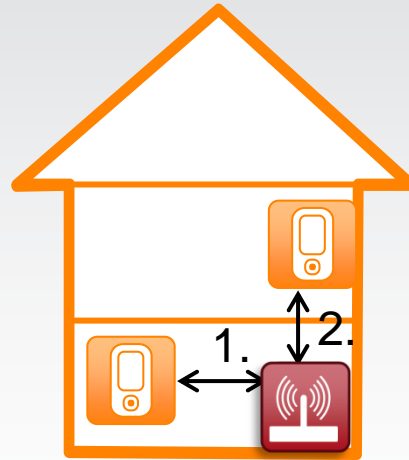
Only family members have access



Single cell

Semi-open residential

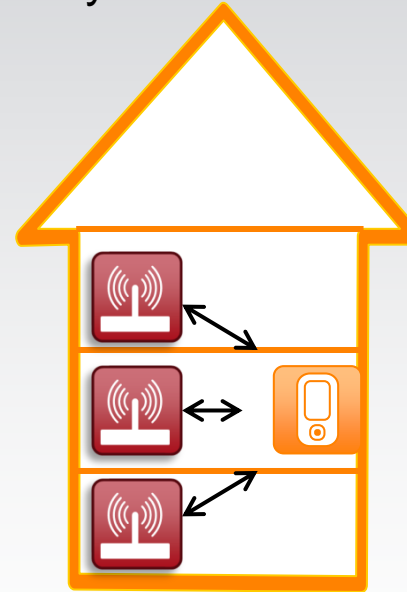
All customers have access, family members prioritized



Single cell

Enterprise

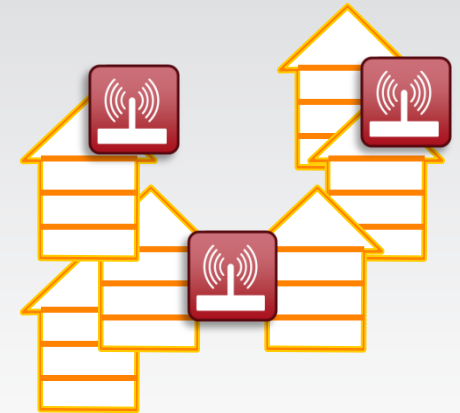
Also multi-cell
Mobility between femtocells



Single and multi-cell

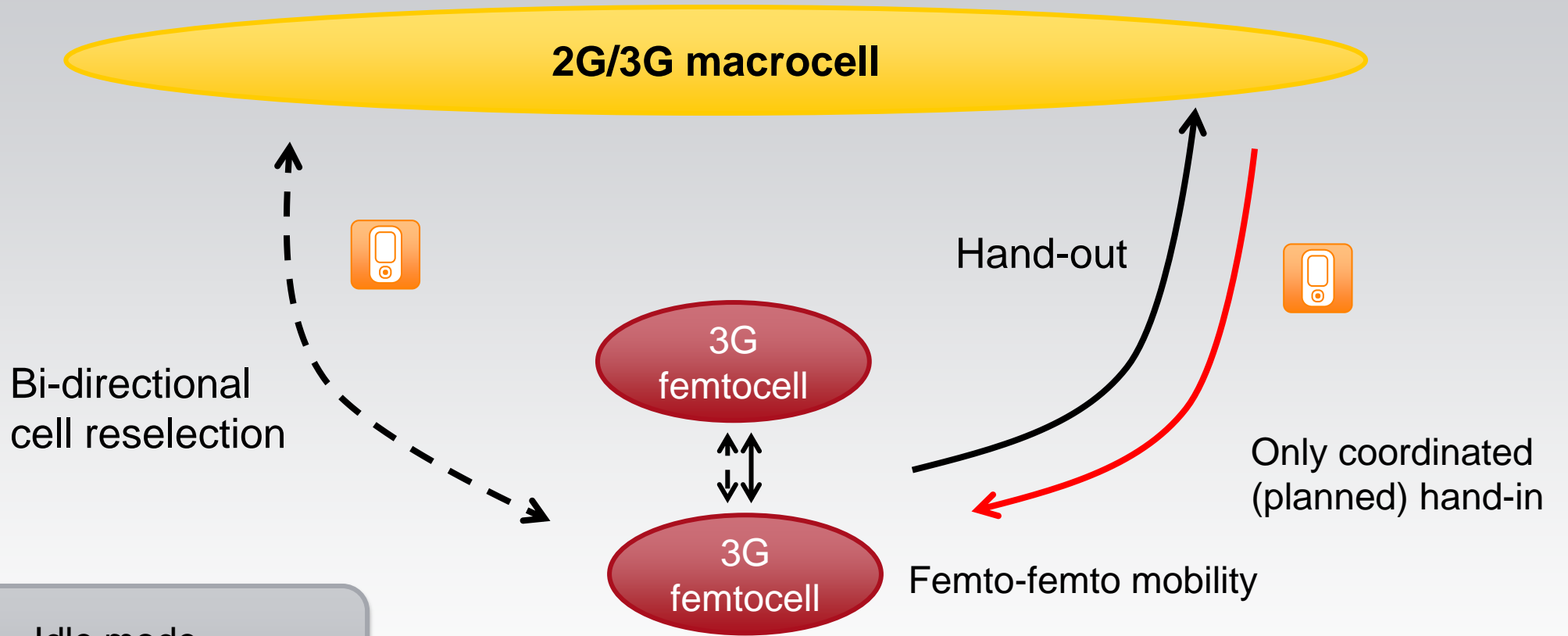
Metro

All customers have access



No significant deployments yet

3G femto mobility



--- Idle mode

— Connected mode

For LTE femtocells full mobility is supported from day one, with enhancements planned in Rel10

Softbank, Japan offers free femtos



- Customer gets FREE femtocell and even ADSL
- Open access, any Softbank subscriber can connect
- Offered to both private and small business customers
- For the owners only \$5 dollars per year electricity cost expected from taking the FAP from Softbank
- Requires 2-year contract



Enhance the Network Available in Households

Provide home femto (small base stations) to households for free



ADSL service exclusively for home femto will be provided for free as well

64

Enhance the Network Available in Shops and Offices



Provide small base stations for free to shops and offices

ADSL service exclusively for femtocell will be provided for free as well

65

Enterprise femto deployment

Network Norway “Full Dekning”

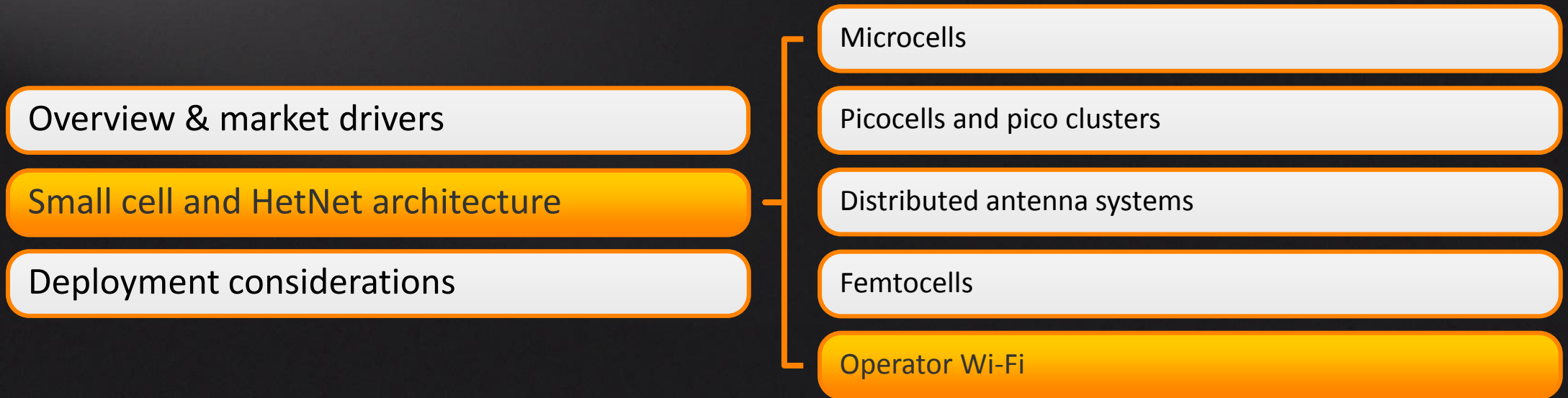


- 99 NOK (13 €) / month, no upfront fee
- Operator installs the FAP
- Also multi-cell with SON features
- Interference control
- Automatic neighbor discovery
- Load balancing



Small cells

Contents



What is operator Wi-Fi?

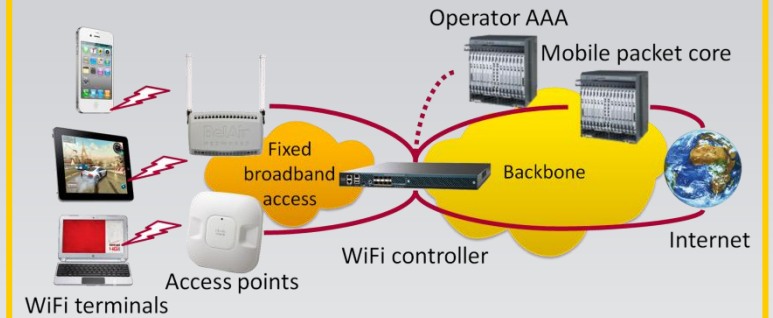
Access points



Site



Network



Indoor

- Output power 20 mW-100 mW
- Size <1 L, <1 kg

Outdoor

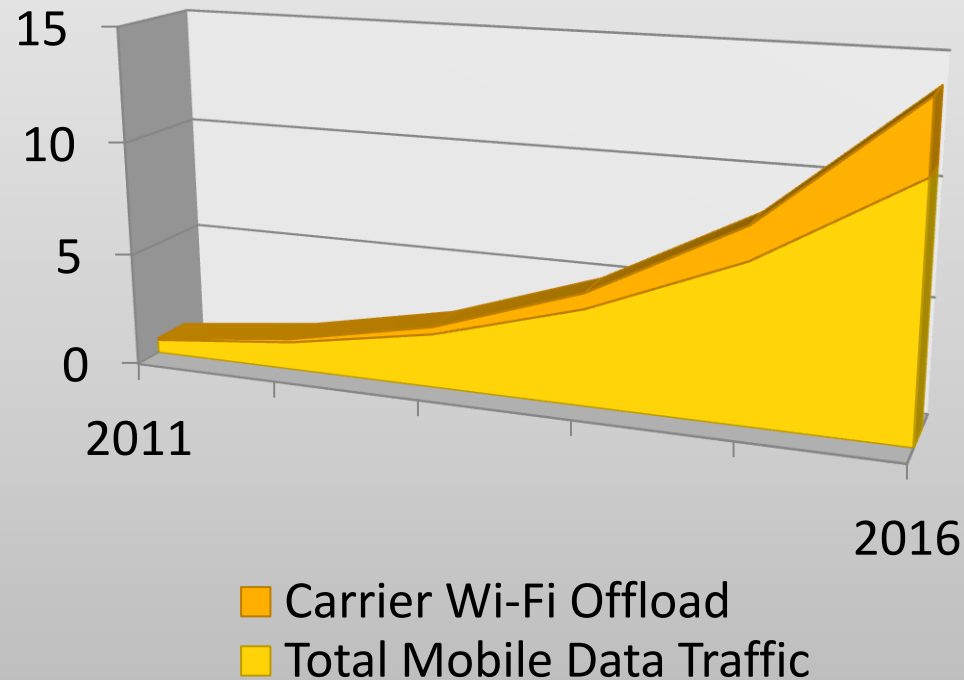
- Output power 0.2 – 1 W
- Coverage radius 10s of meters
- Size 3-8 L, 2-5 kg
- Integrated antenna
- Simultaneous users 20-150

- Increasingly used in public hotspots like restaurants, cafes, transportation hubs and hotels
- Lamp posts, utility poles and building wall outdoor locations
- Municipal, campuses and street-walks popular outdoor locations

- Unlicensed spectrum
- Requires Wi-Fi capable terminals
- Planned or unplanned
- Utilizes controller architecture
- Authentication from operator AAA
- Userplane offloaded or through packet core
- Utilizes fixed broadband backhaul
- Mobility and voice services require additional solutions

Traffic offload from mobile networks to carrier Wi-Fi networks

Global mobile data traffic
Exabytes per month



Source: Cisco, Gartner, Informa

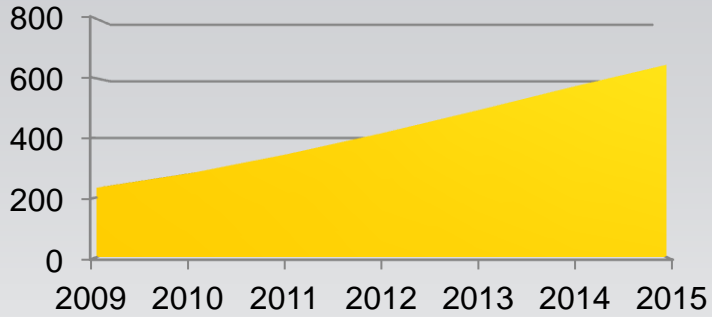
Carrier Wi-Fi offloading from mobile devices grows from 11% in 2011 to 22% in 2016

Share of Wi-Fi capable handsets will grow from under 10% in 2011 to over 50% in 2016

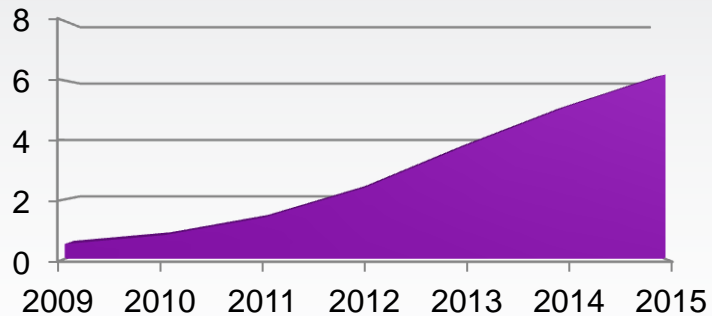
Additionally by 2016 more than 500 million other Wi-Fi capable mobile broadband devices are in use

Strong growth in Wi-Fi hotspots

Private Wi-Fi hotspots (millions)



Public Wi-Fi hotspots (millions)



Source: Informa telecoms & media

Confidential
Small cells & Hetnet

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Nokia Siemens Networks

Topics to consider in the Wi-Fi offloading



Business model

Voice and value added services

Wi-Fi device penetration and availability

Ease of use

Quality of experience (mobility, security, interference)

Three main operator public Wi-Fi offloading target use cases

Customers with cellular devices



- Operator mobile customers
- Consumers and enterprises
- Using smart phones and tablets with SIM and suitable plan
- Target seamless experience
- Service consistency with cellular access desired

Customers with portable devices



- Operator broadband or mobile customers with Wi-Fi plan
- Consumers and enterprises
- Using mobile Wi-Fi devices like laptops, media players and tablets
- Target seamless experience

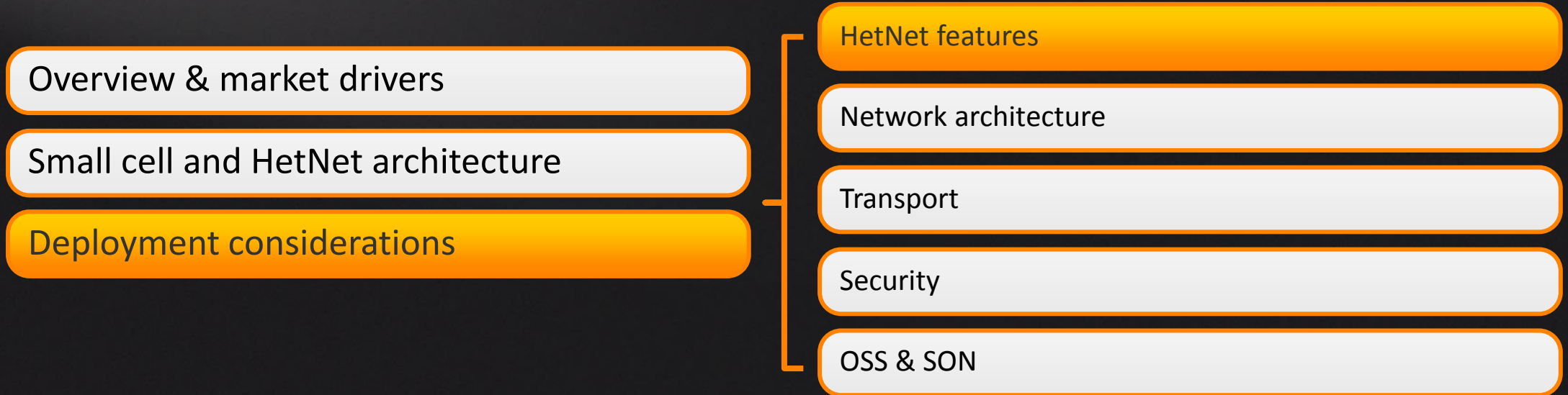
Visitors



- Not customers of operator providing Wi-Fi services
- Consumer and enterprise users
- Smart phones and Wi-Fi devices like media players, laptops and tablets
- Secure on-line charging and authentication

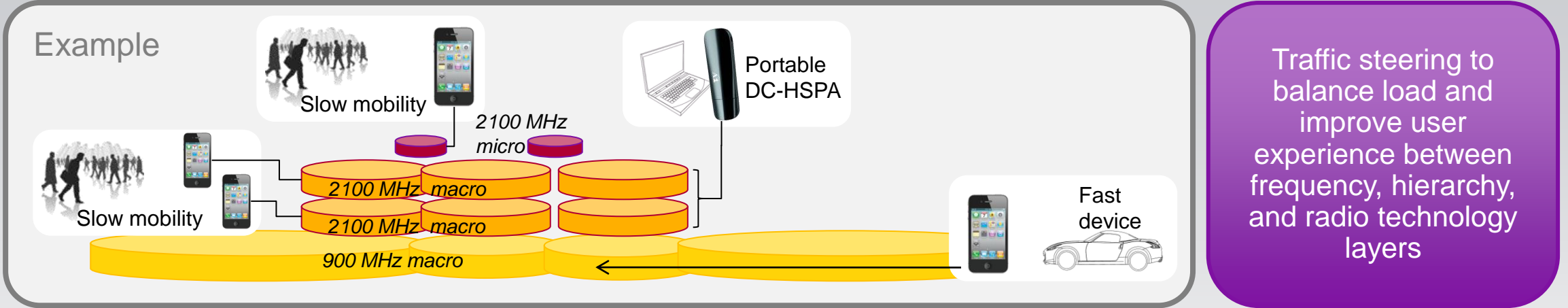
Small cells

Contents



HetNet load balancing features

Managing load and experience in multi-layer, multi-band networks



Traffic steering in idle mode

- Direct devices to the preferred active state use layer to avoid unnecessary handovers and ping-pong for improved network service quality
- Layer selection is steered by adjusting measurement rules, cell reselection priorities, thresholds and offsets and using Smart Connectivity for WiFi (ANDSF)
- Connected state layer change can be based on handover
- Criteria for layer selection: used services, UE velocity, UE and network capabilities matching, load in source and target cells, signal strength

HetNet features

HSPA and LTE small cell range extension

- Range Extension can help to move traffic load to small capacity expansion cells
- Moderate range extension (~3dB) with shared frequency in cell edge areas typically provides good performance gain (3G and LTE)
- LTE Rel10 eICIC allows significantly larger range extension values (10-15 dB) for better small cell utilization

As part of the network planning, macro BTS handover parameters are set so that positive offset is applied to small cell measurements by mobiles

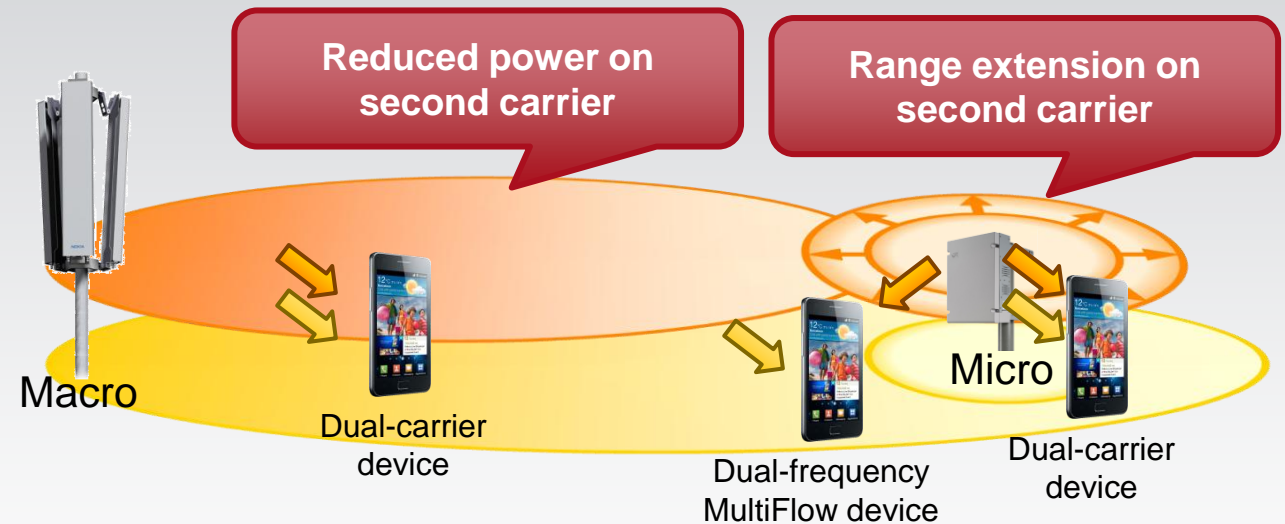
Due this offset – known as Range Extension – mobile will select small cell in worse radio conditions than without Range Extension in place



HetNet features

HSPA multi-carrier MultiFlow downlink range extension (3GPP rel. 11 onwards)

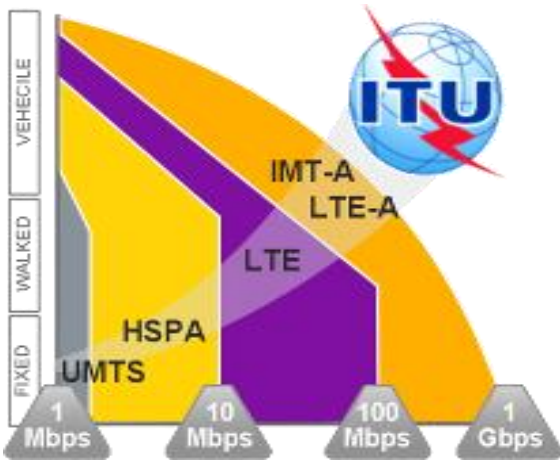
- When multiple carriers are available macro power and range extension can be separately configured for each carrier
- Dual-frequency MultiFlow capable terminals can receive downlink signal from macro and small cell
- HSUPA soft-handover provides similar functionality in uplink
- MultiFlow can be implemented via network software upgrade



LTE-Advanced contains significant small cell features



Smooth migration to LTE-A and backward compatibility with LTE



Heterogeneous Networks



Enables focused capacity enhancement with small cells by interference coordination

Coordinated Multipoint



Capacity and cell edge performance enhancements by active interference cancelation

Relaying



Enables focused coverage extensions with small cells by self-backhaul



8x

MIMO

4x

Carrier Aggregation

up to 100 MHz



Efficient use of small cells



HetNet features

LTE enhanced Inter-Cell Interference Co-ordination (eICIC) (3GPP rel. 10)

Muted subframes known as ABS (Almost Blank)



MACRO cell transmission subframes

During ABS-frames small cells can serve cell edge mobiles



SMALL cell transmission subframes

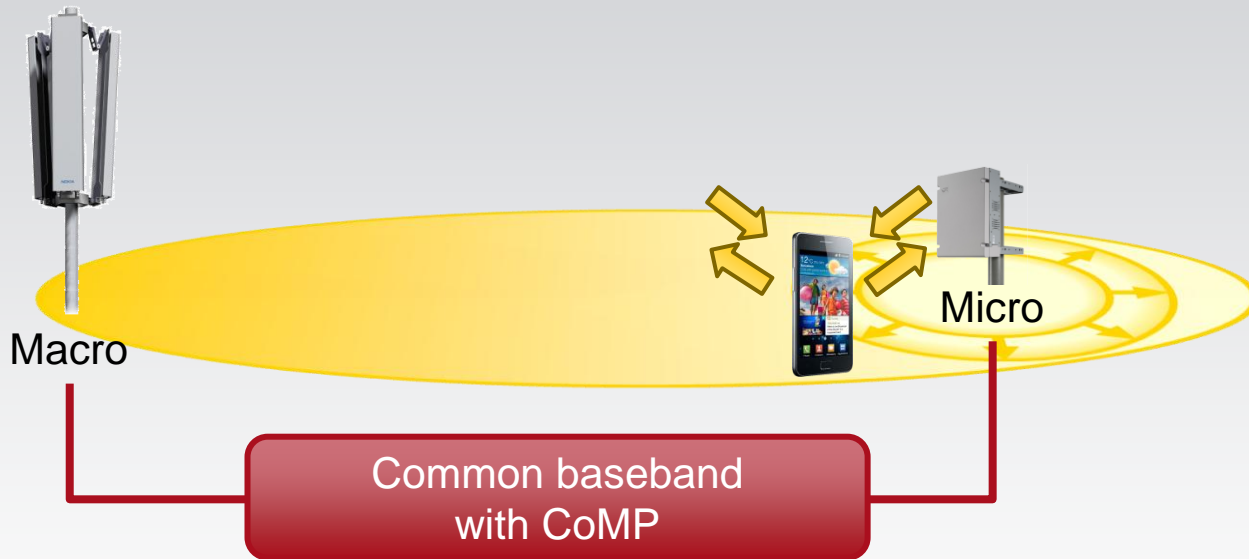
During all subframes good radio condition mobiles served



- eICIC enables larger range extension values + provides better conditions for small cell edge camped mobiles
- Requires Rel10 LTE terminals with eICIC for full benefits

HetNet features

LTE Coordinated Multipoint (CoMP) (3GPP rel. 11 onwards)



- Improved uplink cell edge performance as the same mobile's signal is received by both the macro and small cell
- Improved downlink cell edge performance as data received from small and macro cell
- In practice requires that both macro and small cell have common base band + good fiber transmission

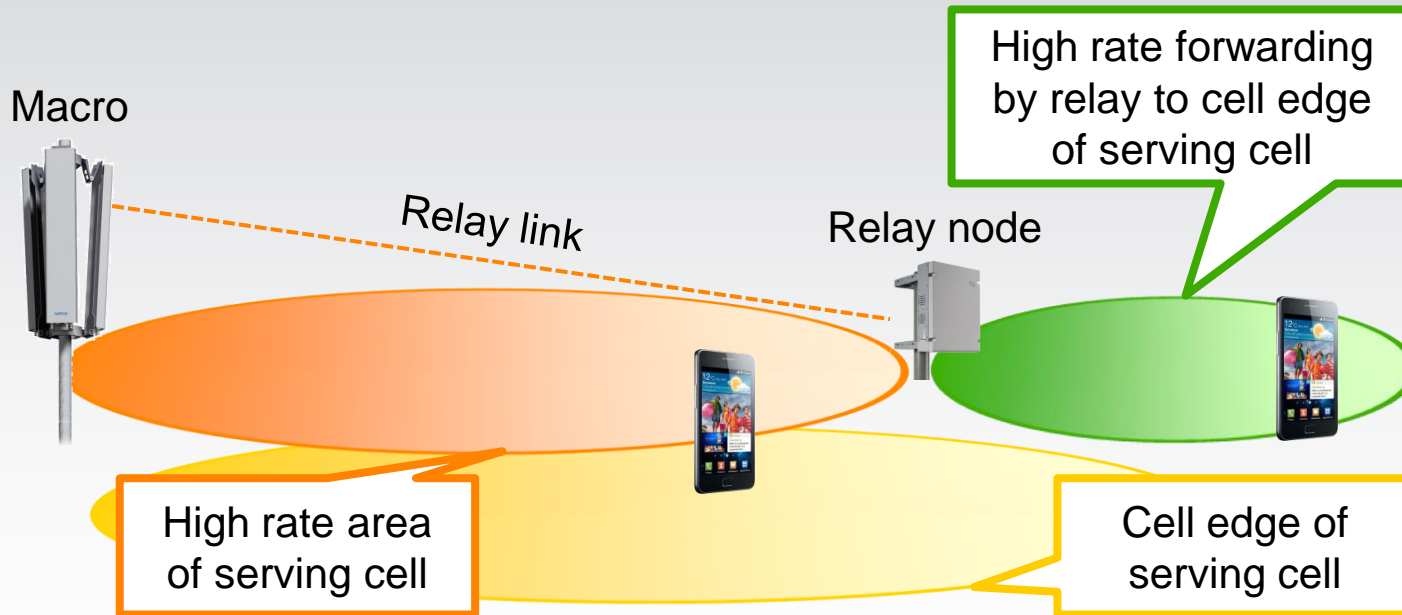
Relaying for improved reach in LTE-Advanced

Concept of self-backhauled base stations

Backhaul provided by an in-band connection

Each relay looks like an independent cell

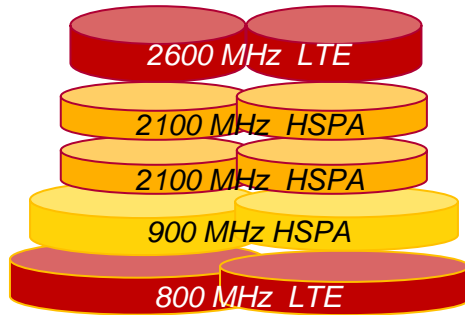
Main focus on single-hop relays



- Improved downlink cell edge performance due to relay signal boost
- Improved uplink cell edge performance from better signal reception by relay node
- Downside is that relay link consumes macro capacity

Cellular mobility management and traffic steering

Homogeneous macro layers



Balance load between macro layers

- Multiple carriers
- Multiple bands
- Multiple technologies

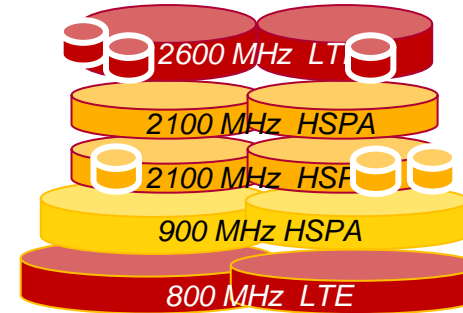
Idle mode steering

- Direct devices to preferred macro layer
- Priorities and power offsets for cell re-selections

Active mode steering

- Service and load based handovers and blind redirections
- Match UE capabilities with network layer capabilities (e.g. MIMO)

Heterogeneous network



Small cell layers creating additional complexity for traffic steering

Further small cell topics for steering

- Avoid fast moving UEs to select small cells
- Balance load ensuring that also small cell layers get traffic
- Cell specific offsets for small cell range extension
- Femto closed subscriber group (CSG) option
- Advanced ANR due to large number of potential (3G) neighbor cells in large scale small cell deployment

Overview of selected 3GPP HetNet features

Emphasis on H(e)NB features, mobility, and interference management

Rel-9

H(e)NB related features such as:

More mobility options (e.g. hybrid and open access mode, HO between HeNBs), operator CSG lists, uplink user plane mux on luh for 3G HNB, LTE HeNB RF requirements, H(e)NB security aspects, H(e)NB OAM support, etc.

Rel-10

Additional H(e)NB architecture improvements such as:

intra 3G HNB-GW mobility, X2 for LTE HeNBs, LIPA/SIPTO in H(e)NB based networks, subsystem performance measurements, etc.

LTE Time-domain enhanced inter-cell interference coordination (TDM eICIC)

Addresses downlink interference management for co-channel scenarios with macro, pico, and HeNB deployment

Rel-11

Further H(e)NB architecture improvements:

Examples include HeNB network sharing, LIPA/SIPTO, more X2 options for HeNBs, etc. ...

Further improvement of LTE TDM eICIC – main focus is on UE interference suppression enhancements

Nokia Siemens Networks/Nokia rapporteur for “Carrier based HetNet ICIC for LTE”

Study item “HetNet mobility improvements for LTE”

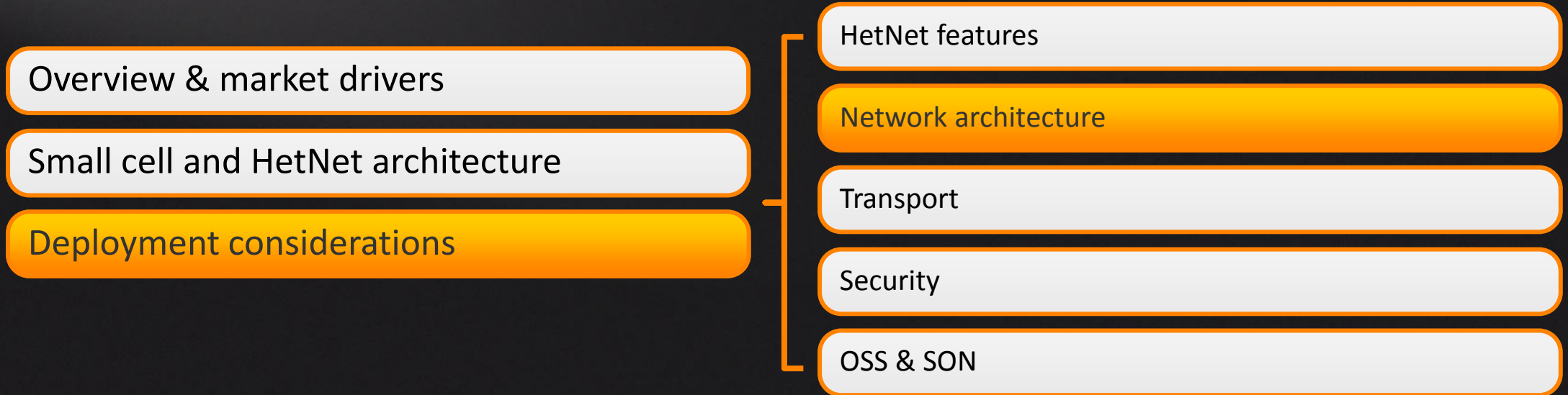
H(e)NB interference management in terms of power control discussed intensively for Rel-9/10 – but without any text going into specs (except for controlling adjacent interference level over macro level)

Thus, today we see many different implementation specific H(e)NB power setting schemes.

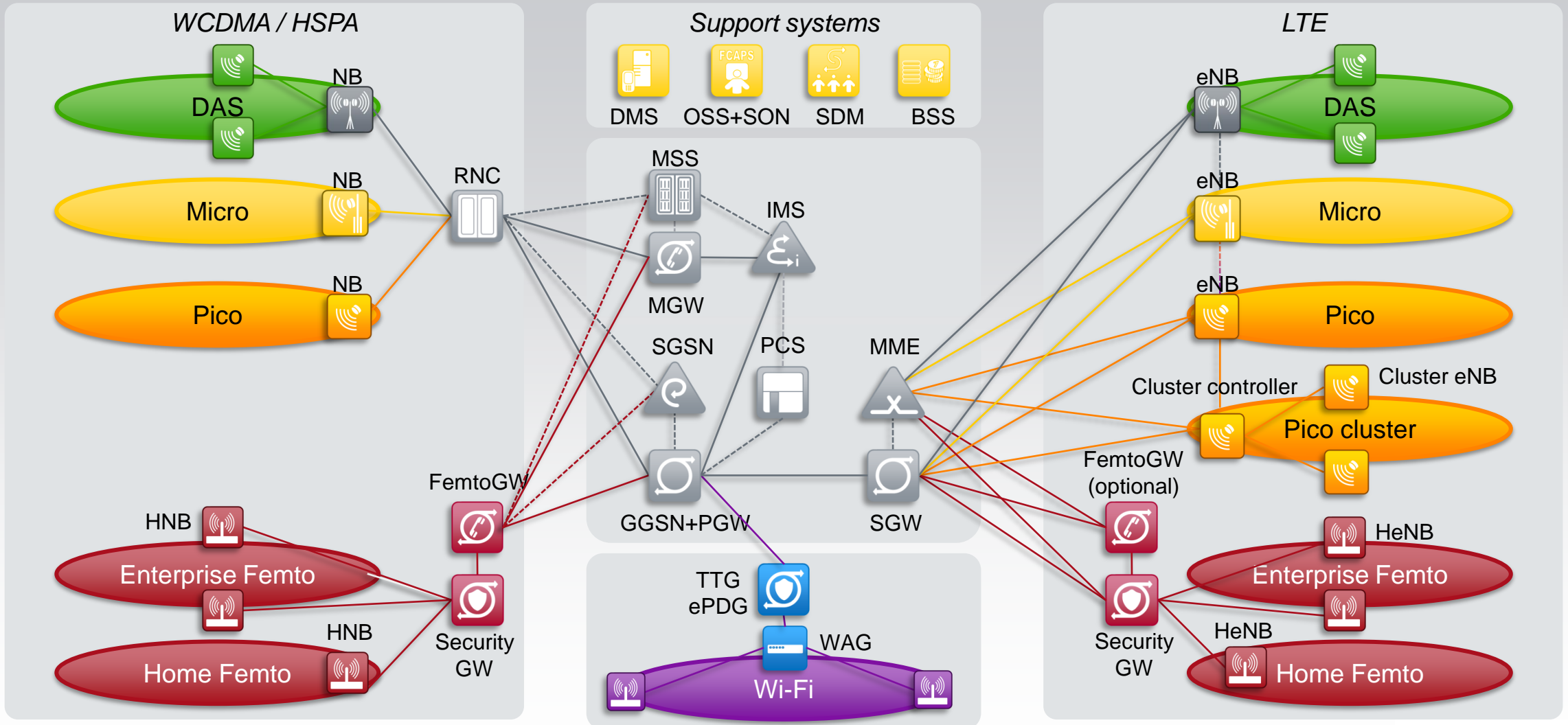
Notice: Currently no 3G HetNet interference management features standardized (except for HNB adjacent channel requirements), and no such proposals for Rel-11. 3GPP HetNet focus seems to be on LTE.

Small cells

Contents



Small cell network architecture



Future small cell solutions for OUTDOOR coverage/capacity

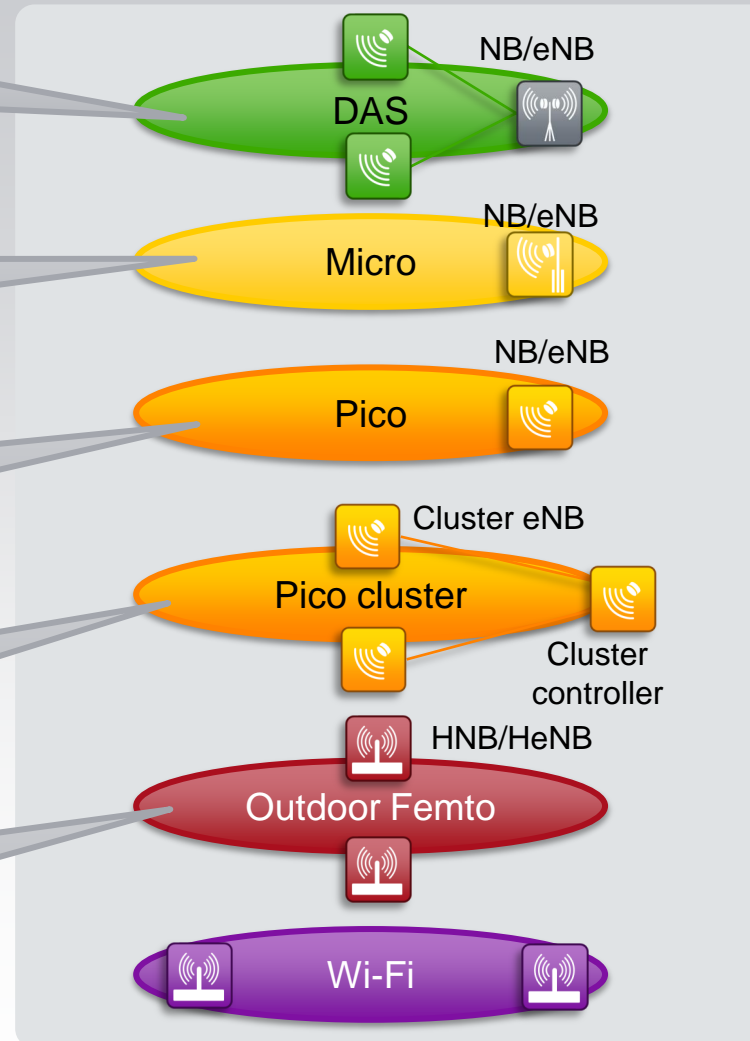
Multioperator solution, expensive to build, today not MIMO capable, widely deployed in the USA

"Default choice" for individual cell sites where macro BTS deployment not feasible

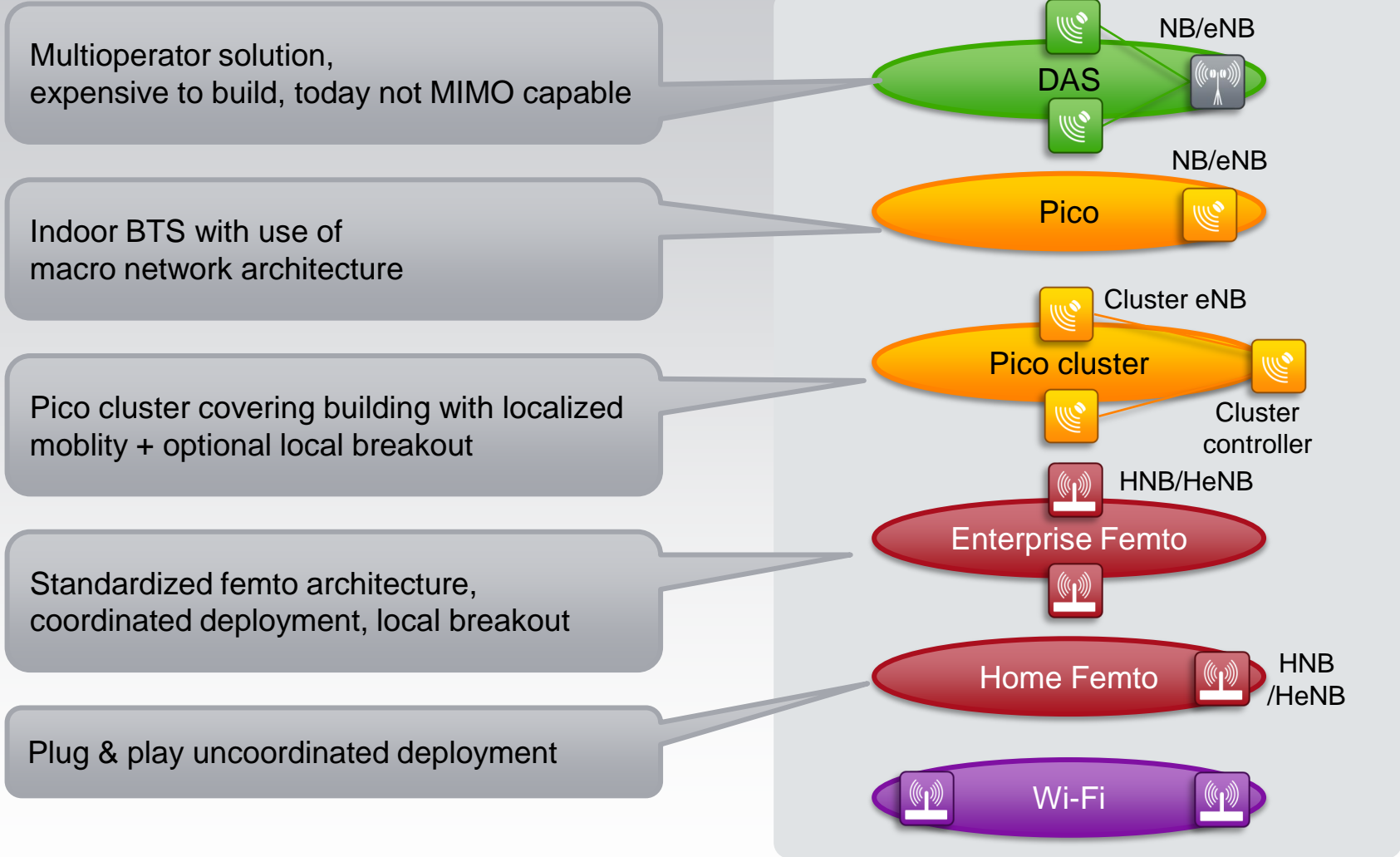
Option for individual cell sites where macro BTS deployment not feasible

Could be used to build larger blanket coverage area by using e.g. lamp posts. Can work with MWR/Wi-Fi backhaul.

Outdoor femtos using standard femto architecture → power levels closer to pico cells. Often called metrocells.

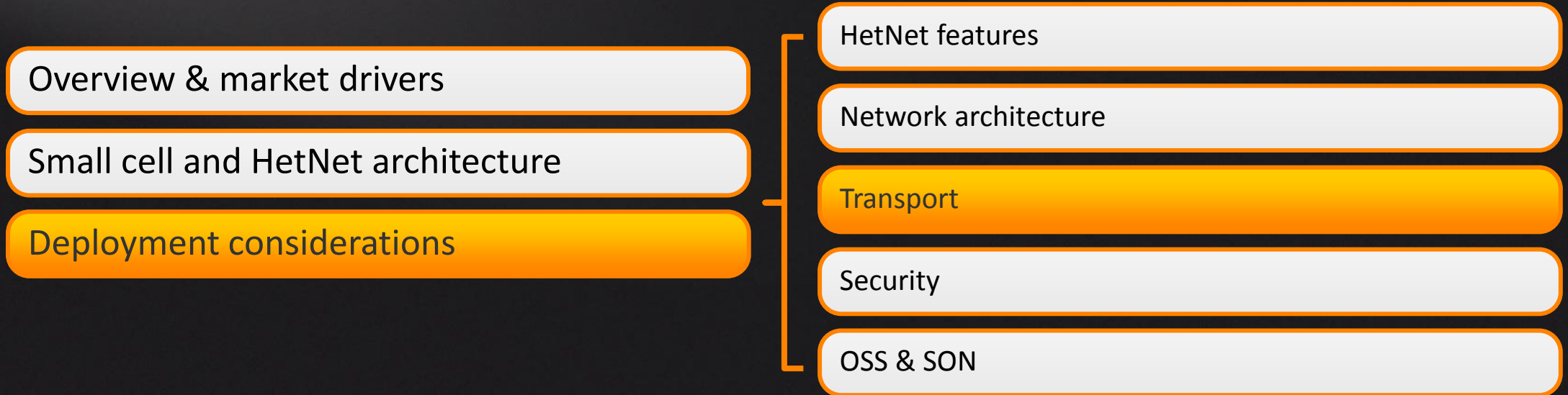


Future small cell solutions for INDOOR coverage/capacity

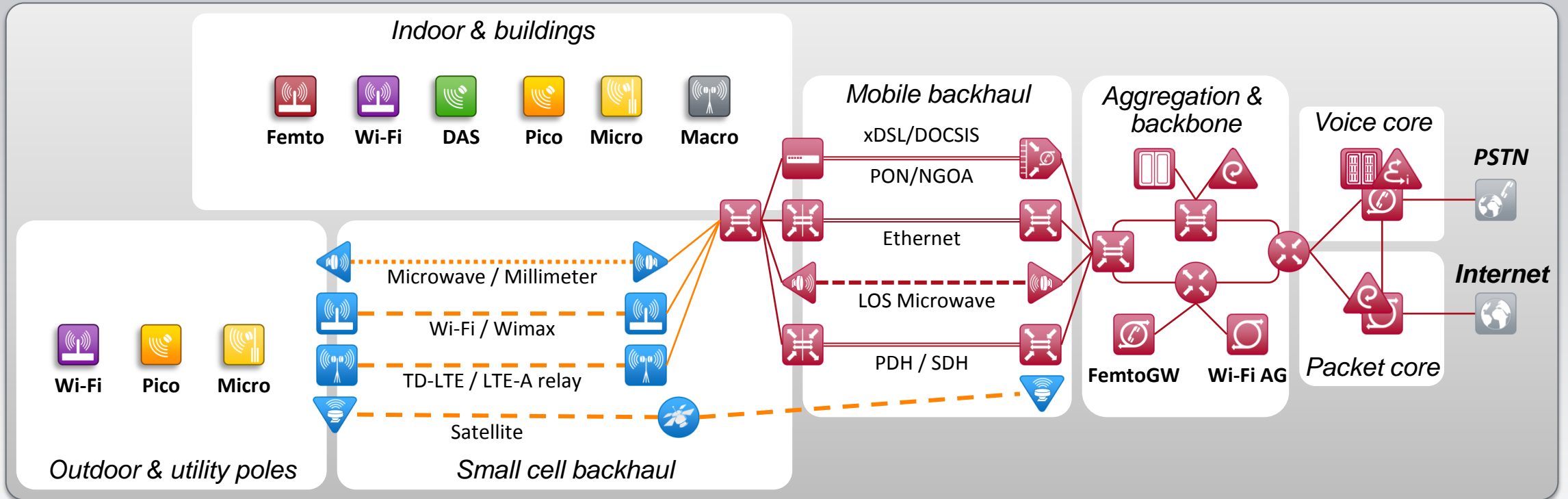


Small cells

Contents



Small cell backhaul options

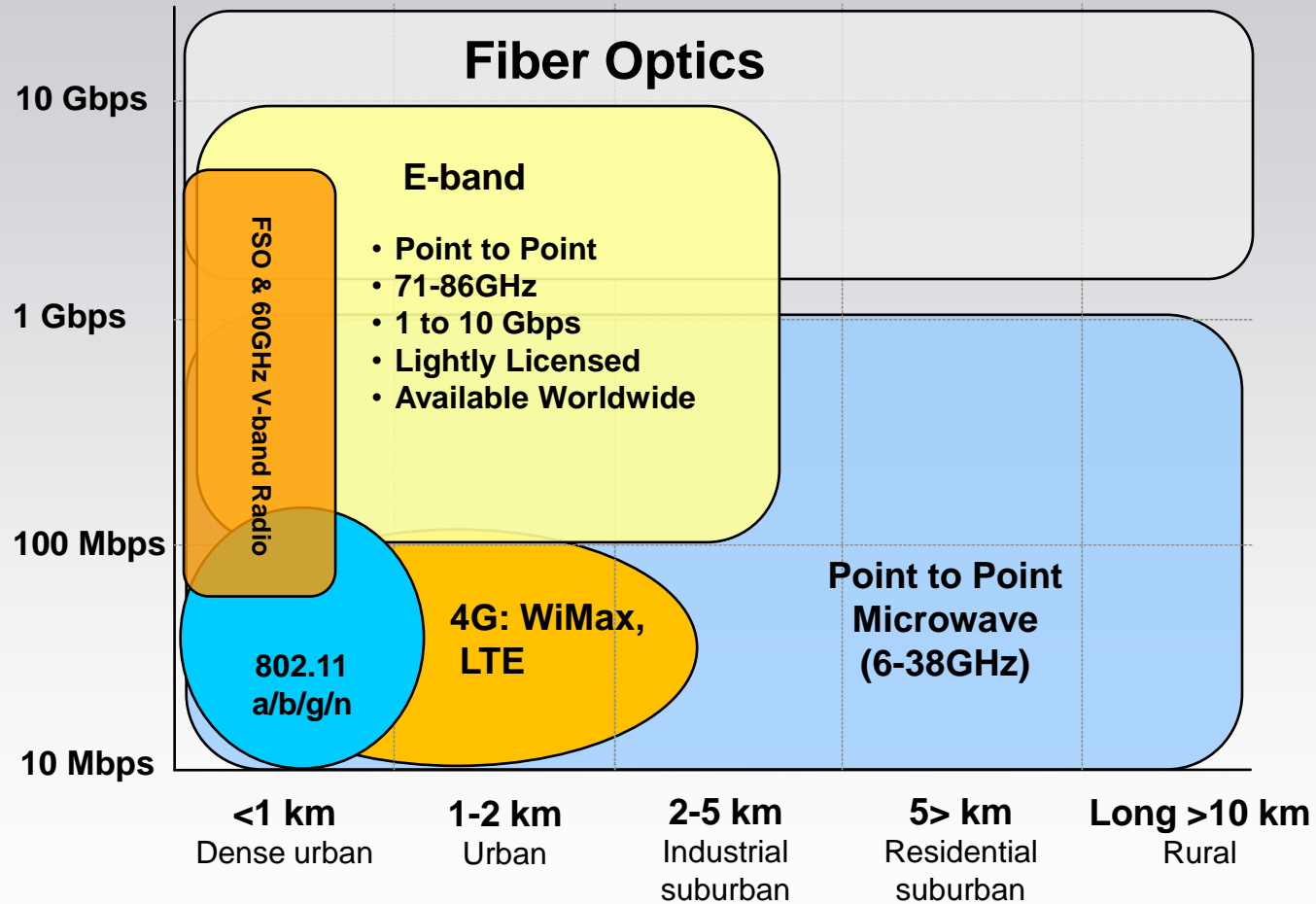


Wireless backhaul is the only practical option when existing fixed infrastructure is not available. Traditional LOS microwave solutions are often too costly for small cells.

Utilize existing macro sites for backhaul aggregation. Leverage existing fixed broadband and Ethernet access where available. Prefer packet only access with timing.

Femto and Wi-Fi can use Internet as backhaul. Start with 20 Mbps for HSPA and evolve to 100Mbps backhaul capacity to match peak rate of HSPA+, LTE and Wi-Fi.

Interesting backhaul technology choices

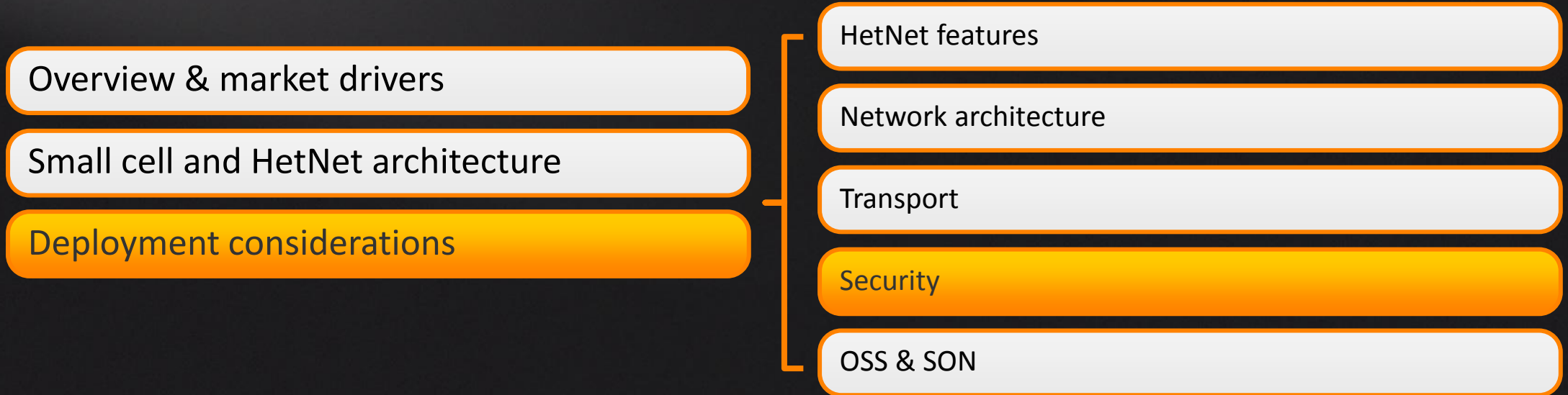


Wireless small cell backhaul options

Technology	Line of sight	Typical bands (country specific)	Band availability	Outdoor max reach	Capacity	Antenna size	Form factor
Microwave	NLOS	2.3, 2.5, 2.6, 3.X, 5.8 GHz	Available but not restricted to microwave backhaul	1 km	40-100 Mbps (10 MHz channel)	<1 foot	All outdoor & very small
Microwave	LOS	6, 11, 18, 23, 38 GHz	Licensed and can be crowded	30 km	10-500 Mbps	1-3 feet	All outdoor or split-mount
Millimeter wave	LOS	60, 76, 86 GHz	Available with light license in most countries	3 km	1,000+ Mbps	1 foot	All outdoor or split-mount
Wimax	NLOS	2.3, 2.5 & 3.5 Ghz	Licensed and expensive	20 km	20-100 Mbps (20 Mhz channel)	<1 foot	All outdoor & very small
FD/TD-LTE, LTE-A	NLOS	FDD/TDD-LTE bands	Licensed and expensive, in-band consumes access capacity	20 km	50-100 Mbps (20 Mhz channel)	<1 foot	All outdoor & very small
Wi-Fi	NLOS	2.4 GHz, 5 Ghz	Unlicensed but crowded	100 meters	20-54Mbps (40Mhz channel)	<1 foot	All outdoor & very small
Satellite	LOS	Ku & Ka	Licensed	Unlimited	1-10 Mbps	1-4 feet	All outdoor

Small cells

Contents



Small cells require new security measures

Small cell security considerations

- Small cell sites and equipment easier to access physically than traditional macro – Indoor Femto and Wi-Fi access points especially easy to access physically
- Outdoor equipment must be protected from weather, vandalism and theft
- Installing rogue base stations or backhaul snooping devices is significantly easier
- Internet often used for backhaul increasing security risks
- Wi-Fi authentication and network identification significantly weaker than cellular networks
- With local breakout attacks from Internet easier to perform

Security threats

Attacks on air interface

- Man in the middle and spoofing
- Identity stealing
- Eavesdropping
- Fraud

Attack on sites

- Theft or vandalism
- Hardware changes or rogue elements
- Software updates or modifications
- Stealing of security keys

Attack on backhaul

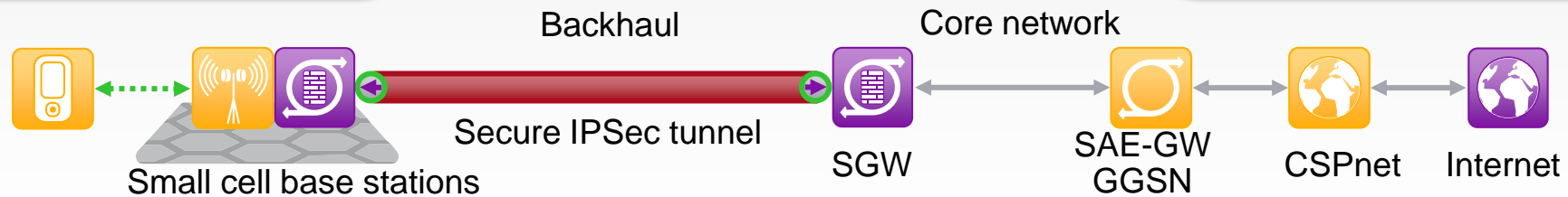
- Eavesdropping
- Denial-of-service

Attacks on controller

- Over backhaul or from Internet

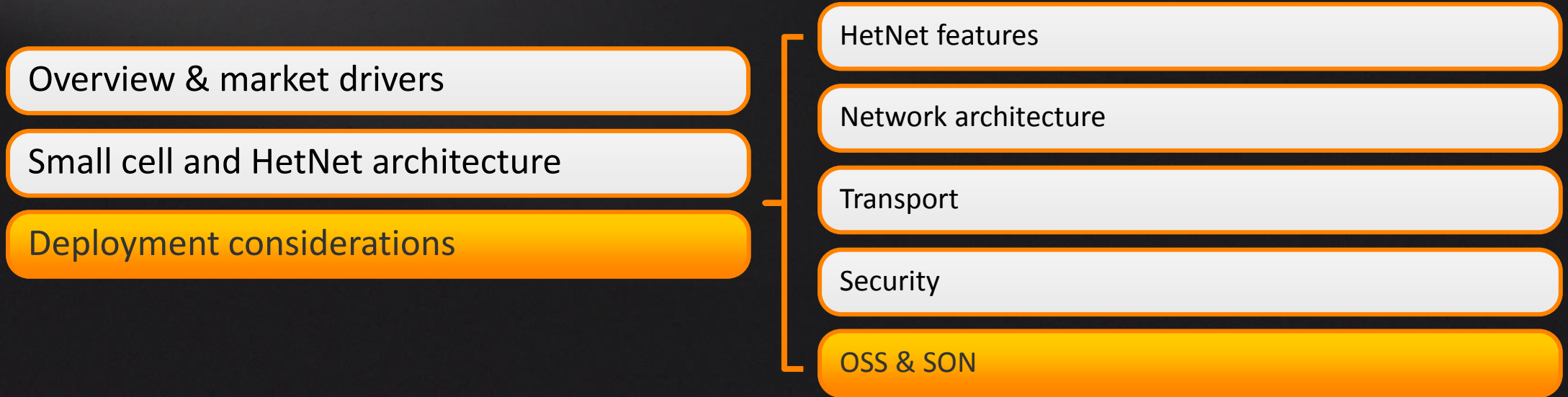
Security solutions

- Tough and weatherproof outdoor enclosures
- Tamper free outdoor mounting
- Separate logical network interfaces for management, signaling and user plane
- Secure remote management solution
- Special attention on security of local diagnostics and management ports
- IPSEC backhaul mutual authentication and encryption – quality of implementation and key management very important
- Independent security audits

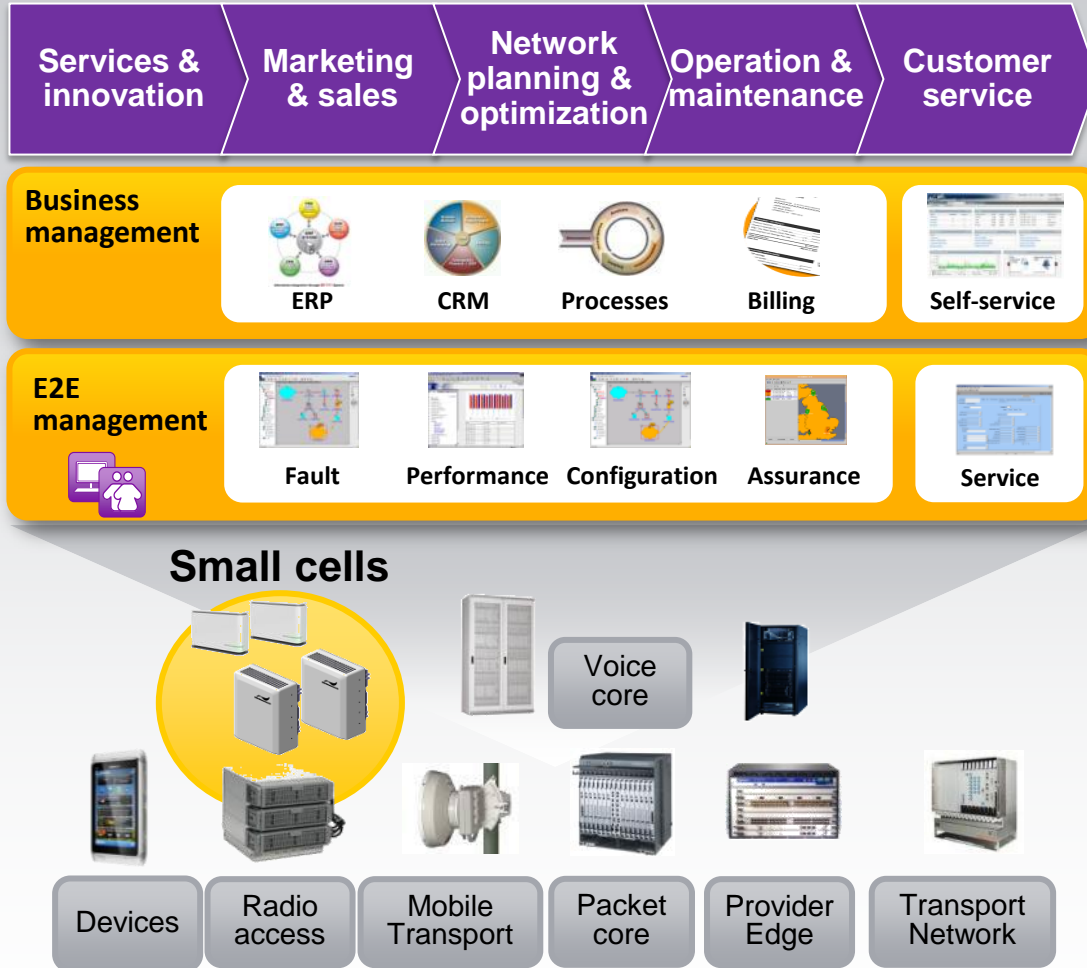


Small cells

Contents



Small cells part of e2e mobile broadband services management



- Small cells seamless part of operator e2e management systems
- Management scalability to large number of BTSs
- Easy plug and play installations
- Automated network management with SON
- Management requirements for small cell transport
- Mobility handovers and interference management between small cells and macro
- Layer optimization management and traffic steering within whole radio access network
- Customer experience management, use and usage reporting

SON automation for Heterogenous Networks



- Automated Neighbour Relationship inter-RAT for LTE, 3G and GSM
- SON Plug and Play network installations
- Load Balancing GSM/3G/LTE
- Mobility management and handover optimization
- InterRAT neighbor relation optimization and synchronization
- Smart energy management
- Self-Healing – automated fault detection, analysis and corrective actions
- SON automation functions for all small cell and macro cell types and network layers

