Panel at 1st DAS Workshop:
Distributed Antenna Systems: Latest advances, opportunities and challenges

Werner Mohr
Nokia Siemens Networks, Munich, Germany
IEEE Globecom 2011, Houston, Texas, USA, December 5 to 9, 2011
Supporting a future with a Gigabyte for each user, everyday

Mobile Broadband Subscriber [Billion]

Source: Nokia Siemens Networks
What will the world want from wireless by 2020? Beyond 4G

**Support up to 1000 times more traffic**

*Mobile data traffic*

- 1 EB
- 1000 EB
- 2010
- 2015
- 2020

**Rock solid, ubiquitous connectivity**

Source: Nokia Siemens Networks

**Apps bandwidth demand**

- 0 Mbps
- 100 Mbps
- 200 Mbps
- 300 Mbps
- HD
- 3D SDTV
- Super HD
- Ultra HD
- 3D HD

**Gbps peak speeds**

Source: Nokia Siemens Networks

**Millisecond latency for true “local feel”**

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How can we build this?

Radio frequency bandwidth capability of base stations:
- 2 MHz
- 20 MHz
- 60 MHz
- 200 MHz

System on Chip enables small radios, low power consumption & integration of intelligent functions. SDR is no problem for digital processing!

Laws of physics determine antenna size:

Switched mode power amplifier, high-voltage GaAs HBT and GaN technologies for wideband radios with multicarrier capabilities:

Continuous growth of computing power with Moore’s law:
- 2 Mn
- 60 Mn
- 2 Bn
- 60 Bn

For same performance, antenna size does not get smaller. Size even increases if beamforming is required.

Source: Nokia Siemens Networks
The Conventional Cellular Architecture

Wireless Cellular Networks: Architecture

• BTS (GSM) or Node B (UMTS)
  - L1 Processing & basic Radio Resource Management (RRM)
• BTS is connected to the BSC (RNC) through cable or microwave links
  - In either case the data is regenerated at the BTS / Node B

Space multiplexing by treating radio signal from other cells as unknown interference

Source: EU Futon project
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The Conventional Cellular Architecture
Network capacity

What would be an obvious solution to increase system capacity?
• Signals from the different cells not treated as unknown interference

Radio signals transported transparently

Allows soft combining / processing at the Central Unit (CU)
• Signals from different cells not treated as interference

Source: EU Futon project
The Conventional Cellular Architecture

Point-to-point capacity issue

- Separate streams at the antennas \( \text{multiplexing gain} \ (R = \min[M_t, M_r]) \)
- But achieved only if the channel is rich scattered
- But in mobile applications, outdoor channels do not have too many major scatterers, resulting in strongly correlated channel
- \( \text{Capacity scaling not sufficiently achieved} \)

For more than one pair of MIMO users interference to each others still exists, requires joint processing of multiple pairs of MIMO links

Solution
- Build a MIMO / DAS system with spatially disjoint antennas and joint processing of different radio signals

Source: EU Futon project
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Optical-Wireless Convergence

- Wireless services should provide high capacity to cope with bandwidth-hungry and sophisticated future services.
- More and more antenna sites are needed to cover a certain area to increase the network capacity.
- Optical fiber is a suitable transmission medium for transporting radio signals to/from the CU.
- The support of more users at higher data rates results in smaller radio cells.
- The complexity/cost of the antenna sites is decreased by providing radio signals from a central unit, where all processing functions occur.

Radio over Fiber (RoF) networks allow for the convergence of wireless and optical access systems.

Source: EU Futon project
Basic concept

- Development of a hybrid optical-radio infrastructure
- Simplified Remote Antenna Units (RAU) are transparently connected to a central unit via radio over fiber (RoF) for joint processing
- Transparent support of legacy (2G, 3G) and future high capacity RATs (LTE, IMT-Advanced) over a single infrastructure
- Facilitate the implementation of Cooperative MIMO and CoMP
- Ease vertical handover

Source: EU Futon project
Basic architecture

- Fixed infrastructure that has enough flexibility to share its resources with a wide range of wired and wireless systems
- Potential to exploit either at the technical or the business level

**Technical level**
- Processing of multi-systems at a single location
- Facilitate the design of efficient cross-system algorithms / protocols
- Interoperability

**Business level**
- Owner of the RoF can be third party
- Existence of an infrastructure that can be rented will support the entrance of new service providers

Source: EU Futon project
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Optical Distribution Network Topologies

Distribution network for support of up to 8 RAUs per CU using CWDM – Coarse Wavelength Division Multiplexing

Distribution network for support of 8 or more RAUs per CU using DWDM (Dense Wavelength Division Multiplexing) and RSOAs (Reflective Semiconductor Optical Amplifier)

Source: EU Futon project
By 2020 - there will be 10x more base stations

Global base station forecast

Number of cellular base stations grows to over 50 Million

80 % will be microcell or smaller

Additionally more than 500 Million WiFi APs

Source: Nokia Siemens Networks

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Liquid Radio – Key elements

Baseband pooling

Active Antenna Systems

Unified and SON enabled Heterogeneous Networks

Active Antenna

RRH

6-sector sites

3-sector RF module

Over 10 Gbps baseband

Beamforming, CoMP

High Load

Low Load

LTE

TD-LTE

HSPA +Femto

HSPA +GSM

Femto

WiFi

Source: Nokia Siemens Networks
Baseband pooling for extreme efficiency
Allocate capacity where the users roam

High Capacity pooling capabilities

- Flexible capacity pooling >10 Gbps
- More efficient coordinated multipoint
- Even leaner sites
- Smart scheduler

Up to 100 cells - with Flexi Multiradio 10 BTS

Source: Nokia Siemens Networks
Heterogeneous Networks – more cells, technologies, bands

LTE networks will coexist in parallel with existing 2G & 3G networks for many more years

Multi-radio traffic and interference management are needed to manage the traffic growth

Smaller cells will enable offload of local high capacity traffic from wide area network

The myriad of cells and layers requires smart optimization and network management solutions

Heterogeneous Networks cannot be handled in the traditional way
Conclusions

- Data traffic will increase significantly in coming years
- Required capacity cannot be provided by additional frequency spectrum
- Distributed antenna systems are one possible solution to overcome the network and link capacity problems by
  - treating interference as useful signal and
  - not as noise
  - Joint processing, CoMP
- Optical fiber infrastructure key enabler for
  - broadband distribution network to Remote Access Units
  - distributed antenna systems for joint processing
  - CRRM algorithms
  - efficient integration of fixed and wireless systems
- Fiber based infrastructure as enabler for new wireless architectures and processing techniques
- Such concepts now applied in deployed systems (e.g. Liquid Radio) to
  - provide sufficient capacity
  - enable flexible centralized signal processing
  - reduce energy consumption for signal processing

Source: Nokia Siemens Networks / EU Futon project
Transmission of 4G wireless technologies

<table>
<thead>
<tr>
<th></th>
<th>Low optical power (3dBm)</th>
<th>High optical power (16dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EVM 8%</td>
<td>EVM 5%</td>
</tr>
<tr>
<td>2.5GHz</td>
<td>~65km</td>
<td>~55km</td>
</tr>
<tr>
<td>10GHz (DSB)</td>
<td>~40km</td>
<td>~35km</td>
</tr>
<tr>
<td>10GHz (SSB)</td>
<td>~55km</td>
<td>~45km</td>
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The results show that RoF is suitable to transmit wireless technologies in access networks, or even metro-access networks.

Source: EU Futon project