ITU Kaleidoscope 2014

Living in a converged world - impossible without standards?

Towards Converged 5G Networks - Challenges and Current Trends

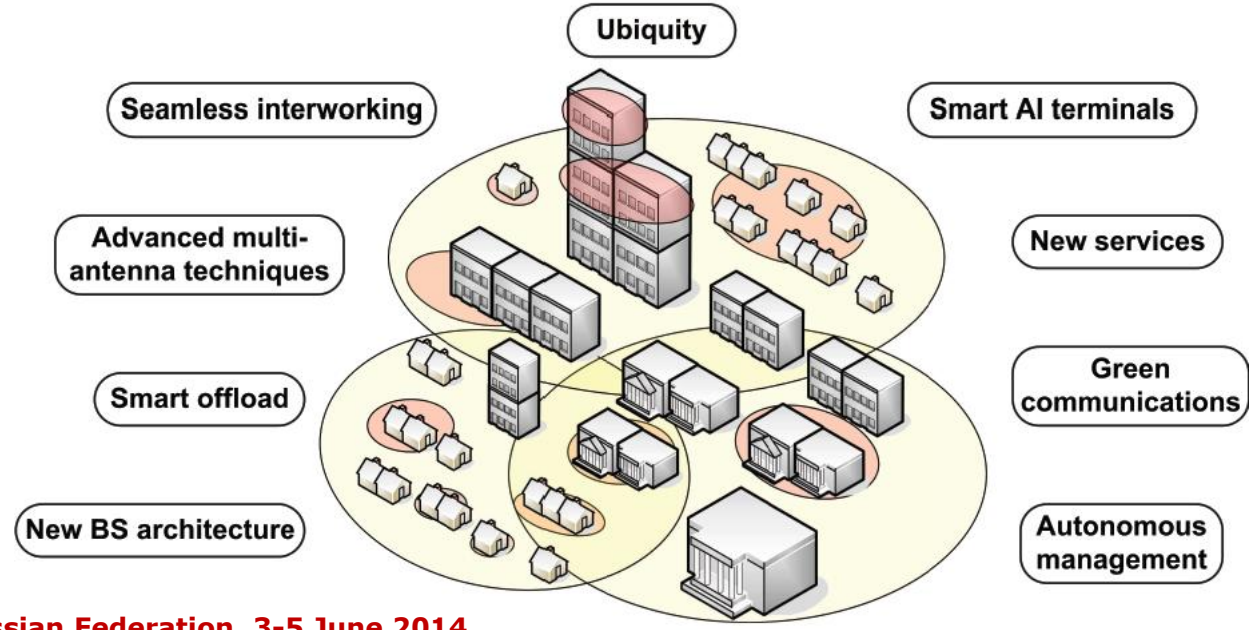
A. Zakrzewska, S. Ruepp, M.S. Berger
DTU Fotonik
Technical University of Denmark
azak@fotonik.dtu.dk

Saint Petersburg,
Russian Federation

Introduction
Future Mobile Networks Expectations

- 10-100x peak data rate
- 1000x capacity
- 10x lower latency
- 10x energy efficiency

Significantly surpass IMT-Advanced



Outline

- Introduction
- Challenges and Development Directions
  - Machine to Machine Communication
  - Capacity Crunch
  - Enhanced Local Area Access
  - New Radio Access Architectures
  - Self-Organising Networks
  - Core Network Virtualisation
- Summary

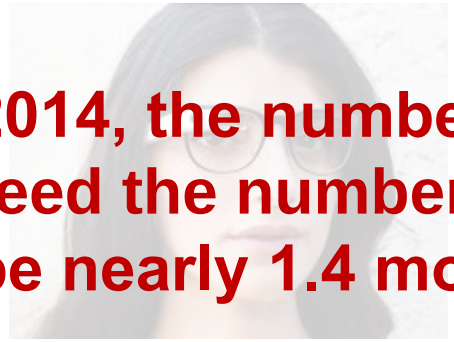
Machine to Machine Communication

- Network and device evolution (revolution?)

“By the end of 2014, the number of mobile-connected devices will exceed the number of people on earth and by 2018 there will be nearly 1.4 mobile devices per capita.”

Cisco, Feb. 2014

http://theinstitute.ieee.org



http://www.google.com/glass

http://www.emro.who.int

http://www.ehi.eu/

- Challenges: enhanced security, radio access techniques, efficient resource management for diverse M2M traffic

Capacity Crunch

Additional spectrum

Higher spectral efficiency

Network densification

More capacity

•Very high spectrum bands (28, 60 GHz)
•Visible light bands, LEDs
•Unlicensed spectrum (2.4, 5 GHz)
•New bands after ITU-R WRC 2015

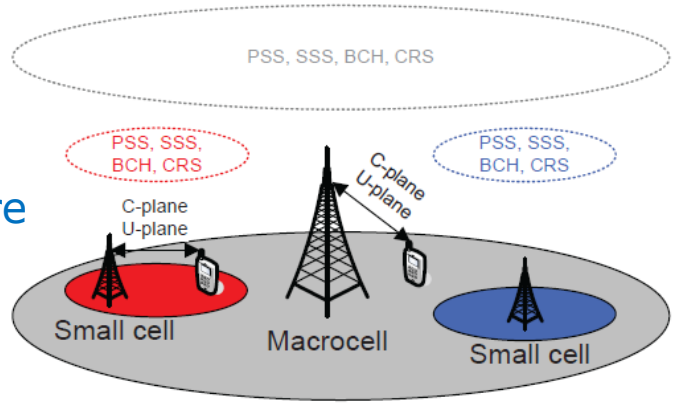
•Spectrum sharing, carrier Aggregation: LTE+HSPA
•Novel multiple access schemes, e.g. NOMA [2]

•HetNet deployment: macrocell overlaying numerous small cells

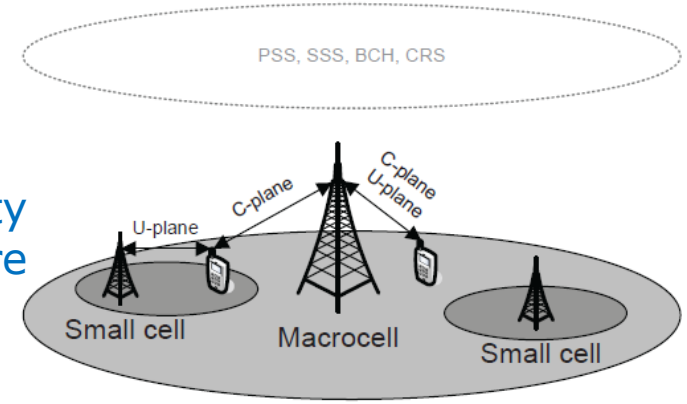
Enhanced Local Area Access

- HetNets boost the network capacity but pose numerous challenges related to mobility
- Dual connectivity: **C-and U-Plane Split**
  - Control-plane provided by the umbrella macrocell
  - User-plane by either the macrocell or the small cell
  - Main advantage: **Reduction of unnecessary handovers and handover failures**

Traditional architecture



Dual connectivity architecture



Enhanced Local Area Access (2)

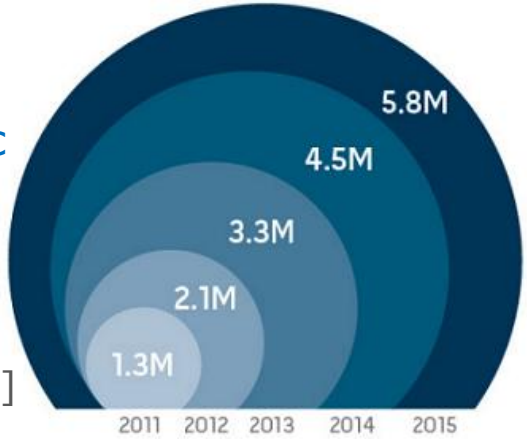
Tighter interworking between cellular and WiFi

- **IEEE 802.11u**
- Automatic authentication and handoff from cellular to WiFi networks
- Offload of cellular data traffic in a seamless way

- **IEEE 802.11s**
- Wireless Mesh Networks (WMNs) to extend public WiFi and offload
- Self-Organizing Network (SON) properties
- Easy and inexpensive deployment (open source firmware)

Number of public hotspots worldwide

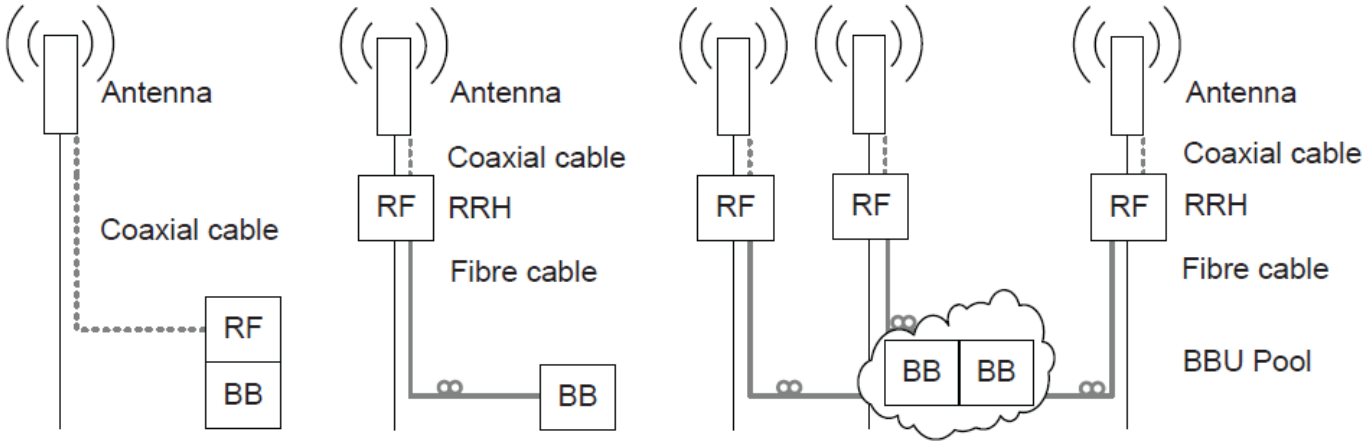
[Wireless Broadband Alliance]



freifunk.net

New Radio Access Architectures
Cloud RAN

- Increasing cost of network deployment and maintenance: **Base station as the most expensive** part-site rental, cooling
  - New BS architectures - **separation of RF from BB**

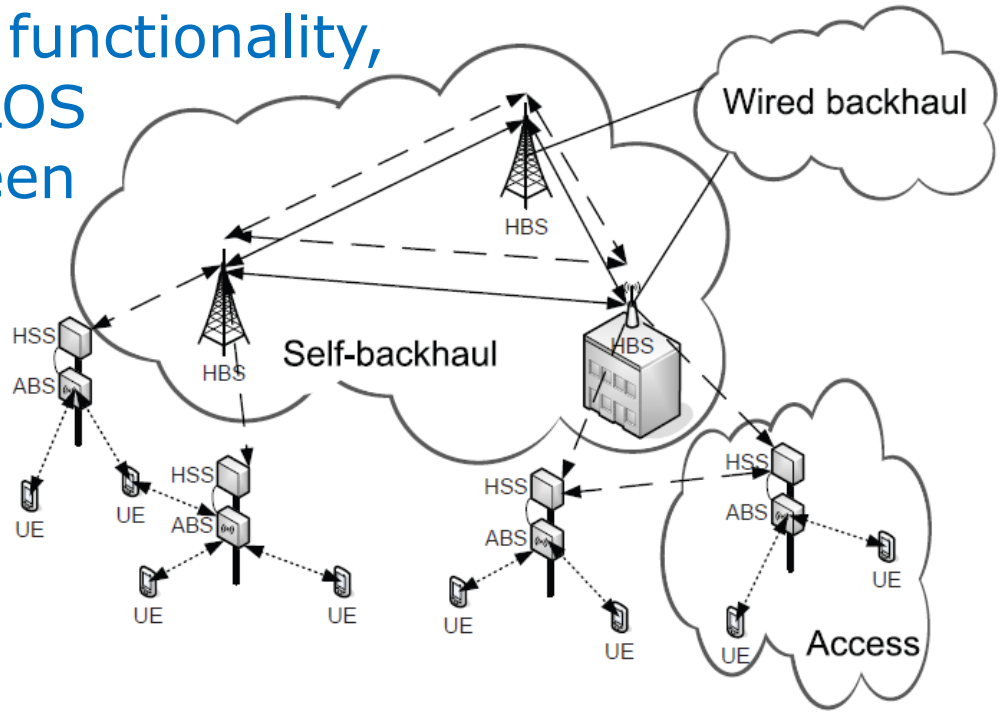


Conventional **Distributed** **Cloud RAN**

  - Variety of architectures, BBU aggregation, reduction of BS sites, adaptability to non-uniform traffic

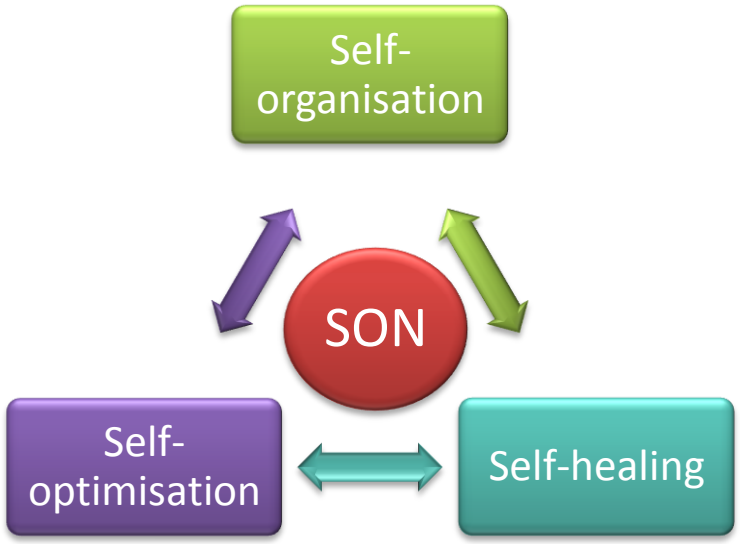
New Radio Access Architectures
BuNGee

- Beyond Next Generation Mobile Networks (BuNGee): Capacity density up to **1 Gbps/km²**
- Contribution to ETSI standardisation
  - **Hub BS** (HBS): core functionality, local centralisation, LOS links at 60GHz between
  - **Access BS** (ABS) provide the service over licensed links
  - Low cost significant increase of network capacity



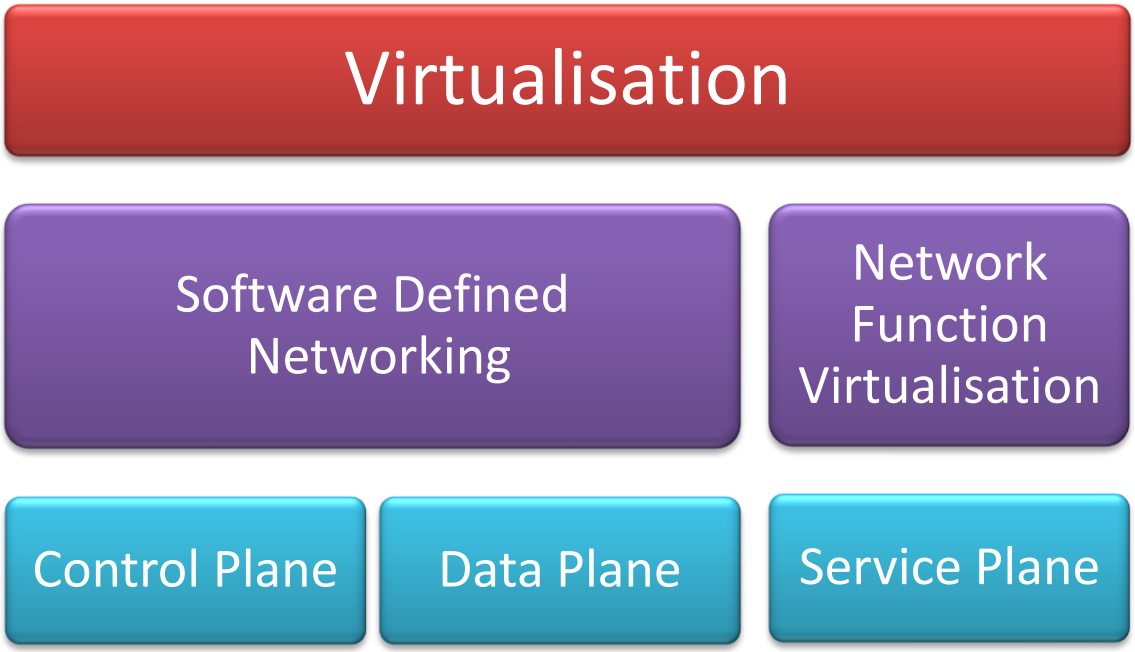
Self-Organising Networks

- Increasing network complexity
  - New **architectures**: multi-RAT, multi-tier, C-RAN
  - New **functionalities**, e.g., Carrier Aggregation (CA)
  - **Resource diversity**: spectral, optical, computational
- Management automation



Core Network Virtualisation

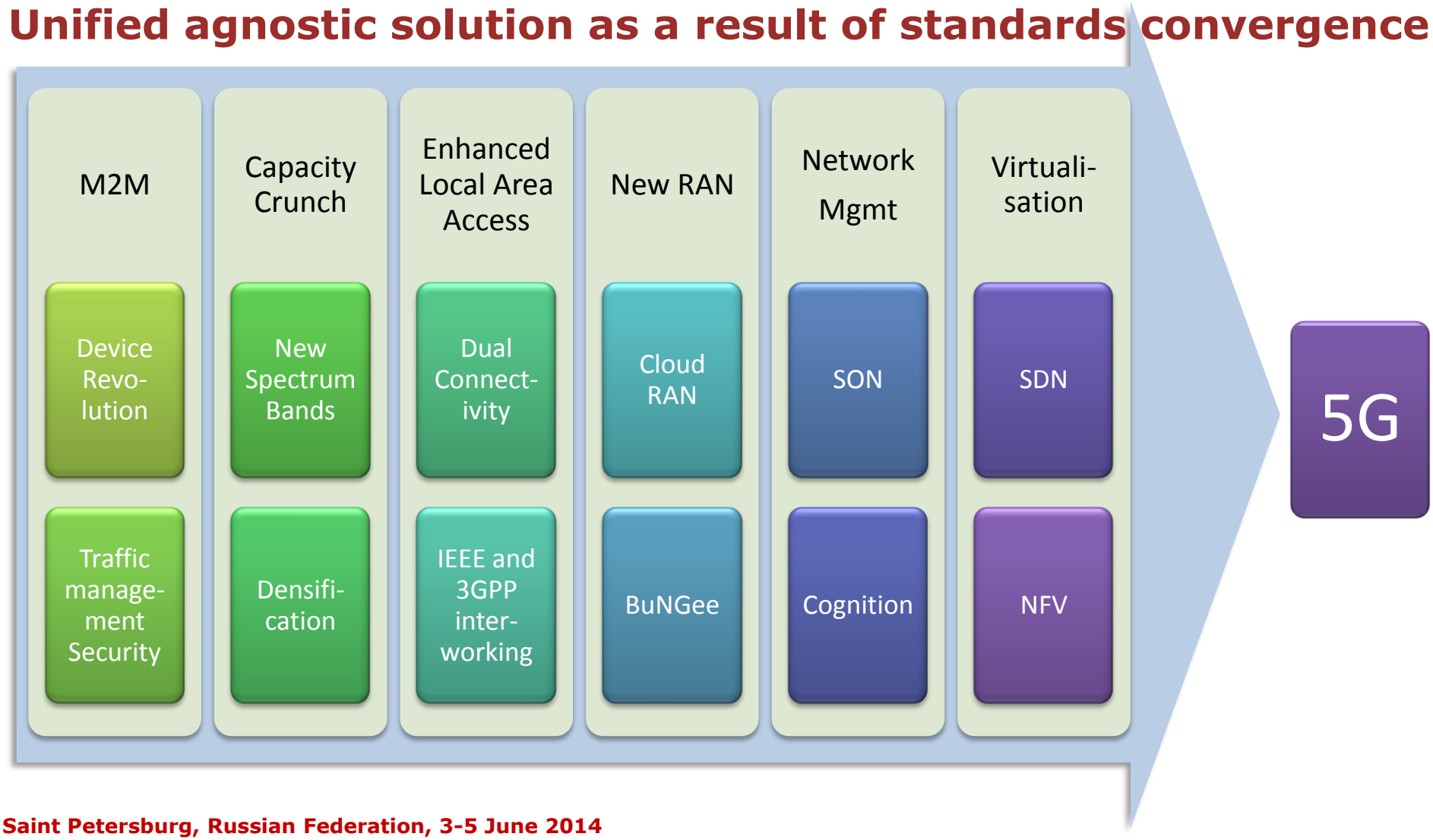
- Hardware and software decoupling



- Scalability, adaptability, faster deployment of new innovative features

Summary

Unified agnostic solution as a result of standards convergence



References

[1] H. Nikopour and H. Baligh, "Sparse code multiple access," in IEEE PIMRC, 2013, pp. 332–336.

[2] Y. Saito, A. Benjebbour, Y. Kishiyama, and T. Nakamura, "System-level performance evaluation of downlink non-orthogonal multiple access (NOMA)," in IEEE PIMRC, 2013, pp. 611–615.

[3] "Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS)," https://www.metis2020.com/.

[4] V. Oleshchuk and R. Fensli, "Remote Patient Monitoring Within a Future 5G Infrastructure," Wireless Personal Communications, vol. 57, no. 3, pp. 431–439, 2011.

[5] Y. Lin, L. Shao, Z. Zhu, Q. Wang, and R. K. Sabhikhi, "Wireless network cloud: architecture and system requirements," IBM J.Res.Dev., vol. 54, no. 1, pp. 38–49, January 2010.

[6] China Mobile Research Institute, "C-RAN The Road Towards Green RAN," White Paper, Version 2.5, Oct. 2011.

[7] ETSI, "Broadband Radio Access Networks (BRAN); Very high capacity density BWA networks; System architecture, economic model and derivation of technical requirements," TR 101 534, European Telecommunications Standards Institute, March 2012.

[8] H. Ishii, Y. Kishiyama, and H. Takahashi, "A Novel Architecture for LTE-B: C-plane/ U-plane Split and Phantom Cell Concept," in IEEE GLOBECOM, Anaheim, USA, Dec. 2012.

[9] H. Haas, "High-speed wireless networking using visible light," in SPIE Newsroom, 2013.

[10] T.S. Rappaport, S. Sun, R. Mayzus, H. Zhao, Y. Azar, K. Wang, G.N. Wong, J.K. Schulz, M. Samimi, and F. Gutierrez, "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!," Access, IEEE, vol. 1, pp. 335–349, 2013.

References (2)

[11] J. Mitola III and Jr. Maguire, G.Q., "Cognitive radio: making software radios more personal," Personal Communications, IEEE, vol. 6, no. 4, pp. 13 –18, Aug 1999.

[12] Nokia Siemens Networks, "2020: Beyond 4G Radio Evolution for the Gigabit Experience," White Paper, 2011.

[13] "5th Generation Non-Orthogonal Waveforms for Asynchronous Signalling (5GNOW)," http://www.5gnow.eu/.

[14] M.R. Boesen, D. Keymeulen, J. Madsen, T. Lu, and T-H. Chao, "Integration of the reconfigurable self-healing eDNA architecture in an embedded system," in Aerospace Conference, 2011 IEEE, 2011, pp. 1–11.

[15] Open Networking Foundation, "SDN Architecture Overview," Dec. 2013.

[16] ETSI, "Network Functions Virtualisation," Oct. 2012, White Paper.

[17] Cisco, "Global Mobile Data Traffic Forecast Update, 2012-2017," Feb. 2013, White Paper.

[18] Q. Zhao and B.M. Sadler, "A Survey of Dynamic Spectrum Access," Signal Processing Magazine, IEEE, vol.24, no. 3, pp. 79–89, 2007.

[19] SCF, "Perspectives on the value of shared spectrum access," Final report for the European Commission, Feb. 2012.

[20] 4G Americas, "HSPA+LTE Carrier Aggregation," http://www.4gamericas.org, June 2011.

[21] Y. Kishiyama, A. Benjebbour, T. Nakamura, and H. Ishii, "Future steps of LTE-A: evolution toward integration of local area and wide area systems," Wireless Communications, IEEE, vol. 20, no. 1, pp. 12–18, 2013.

References (3)

[22] D. Astely, E. Dahlman, G. Fodor, S. Parkvall, and J. Sachs, "LTE Release 12 and Beyond," Communications Magazine, IEEE, vol. 51, no. 7, 2013.

[23] T. Nakamura, S. Nagata, A. Benjebbour, Y. Kishiyama, T. Hai, S. Xiaodong, Y. Ning, and L. Nan, "Trends in small cell enhancements in LTE advanced," Communications Magazine, IEEE, vol. 51, no. 2, pp. 98–105, 2013.

[24] Cisco, "The Future of Hotspots: Making Wi-Fi as Secure and Easy to Use as Cellular," White Paper, 2011.

[25] I. F. Akyildiz and X.Wang, "A survey on wireless mesh networks," Communications Magazine, IEEE, vol. 43, no. 9, pp. S23–S30, 2005.

[26] M. Bennis, M. Simsek, A. Czylwik, W. Saad, S. Valentin, and M. Debbah, "When cellular meets WiFi in wireless small cell networks," Communications Magazine, IEEE, vol. 51, no. 6, pp. 44–50, 2013.

[27] J. Luo, R. Mukerjee, M. Dillinger, E. Mohyeldin, and E. Schulz, "Investigation of radio resource scheduling in WLANs coupled with 3G cellular network," Communications Magazine, IEEE, vol. 41, no. 6, pp. 108– 115, 2003.

[28] A. Zakrzewska and V. B. Iversen, "Resource sharing in heterogeneous and Cloud Radio Access Networks," in Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), 2012 4th International Congress on, Oct. 2012, pp. 34–39.