UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"5G, Beyond 5G and 6G: the next frontier"

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Short Abstract:

In the last years, information communication, computation and storage technologies are jointly reshaping the way we use technology, meeting the future needs of a wide range of big data and artificial intelligence applications and, paving the way for a full customized autonomous user experience. In 2020 the 5G -Next Generation Communication Networks is expected to be operational and a global game changer from a technological, economic, societal and environmental perspective. 5G industry is intensively working today on designing, prototyping and testing fundamental technological advances to de-liver the promised performance in terms of latency, energy efficiency, wireless broadband capacity, elasticity, etc. Nevertheless, many experts say that the next big step for cellular networks is not 5G, it is the cloud. This lecture will cover both architecture and detail technical tools for understanding the key enabling technologies that will enable 5G networks to meet its challenging performance targets and how 'the cloud' will play an operational role in future wireless networks.

Course Contents in brief:

1. Introduction to evolution of Wireless Networks from 3G+ to 5G. Details on technologies enabling the revolution between 4G and 5G networks.
2. Network densification, resource management and heterogeneous networks
3. Advanced interference management techniques from heuristics to information theory
4. Millimeter waves, Massive MIMO and antenna design Energy efficiency and its advanced techniques
5. The 'cloudification' of 5G: from central-RAN to mobile edge cloud. Details examples of convex optimization tools and millimeter wave spectrum use
6. Energy efficiency and its advanced techniques
7. 6G the next frontier of research: Vision, roadmaps, enabling technologies.

Total # of hours: 20

References:

Green Communications

- *Enabling green cellular networks: A survey and outlook,* Antonio De Domenico, Emilio Calvanese Strinati, Antonio Capone,

- *Green framework for future heterogeneous wireless networks*, R Mahapatra, A De Domenico, R Gupta, EC Strinati – Journal on computer networks, 2013.

- *Base-station duty-cycling and traffic buffering as a means to achieve green communications,* R Gupta, EC Strinati, IEEE VTC 2012.

- Green communications: an emerging challenge for mobile broadband communication networks, E Calvanese Strinati, A De Domenico, L Herault - Journal of Green Engineering, 2011.

6G

- *6G: The Next Frontier: From Holographic Messaging to Artificial Intelligence Using Subterahertz and Visible Light Communication*, EC Strinati, S Barbarossa, JL Gonzalez-Jimenez, D Ktenas, IEEE VT Magazine, Septembre 2019.

- *Air Interface Challenges and Solutions for future 6G Networks,* B Miscopein, JB Doré, E Strinati, D Kténas

Mobile Edge Cloud

- *Resilient Design of 5G Mobile-Edge Computing Over Intermittent mmWave Links,* N di Pietro, M Merluzzi, EC Strinati, S Barbarossa, arXiv preprint, October 2019.

- *Proactive Computation Caching Policies For 5G-and-Beyond Mobile Edge Cloud Networks,* N di Pietro, EC Strinati, EUSIPCO 2018.

- *Enabling effective mobile edge computing using millimeterwave links*, S Barbarossa, E Ceci, M Merluzzi, E Calvanese-Strinati, IEEE ICC 2017.

- *Dynamic resource allocation exploiting mobility prediction in mobile edge computing*, J Plachy, Z Becvar, E Calvanese Strinati - 2016 IEEE WCNC.

- *Uplink traffic in future mobile networks: Pulling the alarm*, J Oueis, E Calvanese Strinati, Crowncom 2016.

- *The fog balancing: Load distribution for small cell cloud computing*, J Oueis, E Calvanese Strinati, S Barbarossa - 2015 IEEE VTC.

- *An architecture for mobile computation offloading on cloud-enabled LTE small cells*, F Lobillo, Z Becvar, MA Puente, P Mach, E Calvanese Strinati, IEEE WCNC 2014.

- Small cell clustering for efficient distributed fog computing: A multi-user case, J Oueis, EC Strinati, S Sardellitti, S Barbarossa - 2015 IEEE VTC.

- *Dynamic Traffic Management for Green Open Access Femtocell Networks*, A De Domenico, R Gupta, E Calvanese Strinati, IEEE VTC 2012.

CV of the Teacher

Dr. Emilio Calvanese Strinati obtained his Engineering Master degree in 2001 from the University of Rome 'La Sapienza' and his Ph.D in Engineering Science in 2005. He then started working at Motorola Labs in Paris in 2002. Then in 2006 he joint CEA/LETI as a research engineer. From 2007, he becomes a PhD supervisor. From 2010 to 2012, Dr. Calvanese Strinati has been the co-chair of the wireless working group in GreenTouch Initiative which deals with design of future energy efficient communication networks. From 2011 to 2016 he was the Smart Devices & Telecommunications European collaborative strategic programs Director. Since December 2016 he is the Smart Devices & Telecommunications Scientific and Innovation Director. In December 2013 he has been elected as one of the five representative of academia and research center in the Net!Works 5G PPP ETP. From 2017 to 2018 he was one of the three moderators of the 5G future network expert group. Between 2016 and 2018 he was the coordinator of the H2020 joint Europe and South Korea 5GCHAMPION project. Since July 2018 he is the coordinator of the H2020 joint Europe and South Korea 5G-AllStar project. Since 2018 he holds the French Research Director Habilitation (HDR).

 E. Calvanese Strinati has published around 120 papers in international conferences, journals and books chapters, given more than 100 international invited talks, keynotes and tutorials. He is the main inventor or co-inventor of more than 60 patents. He has organized more than 80 international conferences, workshops, panels and special sessions on green communications, heterogeneous networks and cloud computing hosted in international conferences as IEEE GLOBCOM, IEEE PIMRC, IEEE WCNC, IEEE VTC, EuCnC, IFIP, EUCnC and European Wireless.

Room and Schedule

Room: *Aula Riunioni, Dipartimento di Ingegneria dell'Informazione, Largo L. Lazzarino 1, 56122 Pisa, Edificio A, piano 6*

Schedule:

N.	Lesson	Day
1	**Before 5G: details on technologies enabling the 5G evolution and revolution.**	6 July 2020 - 9:00-12:00
1	**5G definition and challenges**	6 July 2020– 12:00-13:00
2	**5G key technology enablers**	7 July 2020- 9:00-10:00
2	**5G Issues & solutions: energy efficiency, Resource orchestration, Adaptive mechanisms**	7 July 2020- 10:00-13:00

3	Advanced interference management techniques from heuristics to information theory	8 July 2020 - 9:00-11:00
3	The 'cloudification' of 5G: from central-RAN to mobile edge cloud. From Virtualization, to network slicing and cloudification	8 July 2020 - 11:00-13:00
4	Mobile Edge Cloud in 5G : clustering, computational offloading principles, proactive content caching, energy Efficiency and latency constraints. Details examples of convex optimization tools.	9 July 2020 - 9:00-12:00
4	The edge eating the cloud: where ends the edge?	9 July 2020 - 12:00-13:00
5	Mobile Edge Cloud open research topics for 6G: where ends the edge? cloud architecture and joint communication, computation and caching challenge. Advanced proactive caching, Millimiterwaves and MEC: opportunities and issues, energy Efficiency, EMF.	10 July 2020 - 9:00-11:00
5	6G the next frontier of research: Vision, roadmaps, enabling technologies	10 July 2020 - 11:00-13:00