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Centre for intelligent electricity distribution - to empower the future Smart Grid

#### **5G communication for smart grid applications**

CINELDI Conference, 09.04.2019

Michele Garau

# The evolution towards 5G From 4G to 5G

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#### Mobile 4G LTE LTE, LTE Advanced Mobile 3G CDMA2000/EV-DO Faster and Better Mobile Broadband WCDMA/HSPA+, TD-SCDMA Mobile 2G More Data Capacity D-AMPS, GSM/GPRS, Mobile Broadband cdmaOne Data Optimized Mobile 1G Mobile for the Masses AMPS, NMT, TACS More Voice Capacity SGR **Lte** Foundation of Mobile Lte Seamless Mobility A GLOBAL INITIATIVE 36 GENERATION PARTNERSHIP PROJECT 2 '36PP2' ..... 1010110100111000 **5G** 1980s 1990s 2000s 2010s 2020 N/A <0.5 Mbps 63+ Mbps 300+ Mbps **Analog Voice Digital Voice + Simple Data Mobile Broadband Faster and Better** R **₽**0 LIVE C 1 **Richer Content** More (Video) Connection

Adapted from: https://www.qualcomm.com/media/documents/files/qualcomm-5g-vision-presentation.pdf



L. Mamushiane and S. Dlamini, "Leveraging SDN/NFV as key stepping stones to the 5G era in emerging markets," in 2017 Global Wireless Summit (GWS), 2017, pp. 23–27. X. Foukas, G. Patounas, A. Elmokashfi, and M. K. Marina, "Network Slicing in 5G: Survey and Challenges," *IEEE Communications Magazine*, vol. 55, no. 5, pp. 94–100, May 2017. https://www.gualcomm.com/media/documents/files/gualcomm-5g-vision-presentation.pdf

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#### The 5G concept



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D. Savu and S. Stancu, "Software Defined Networking: technology details and openlab research overview," presented at the IT Technical Forum, CERN openlab, 14-Feb-2014.



P. E. Heegaard, B. E. Helvik, G. Nencioni, and J. Wäfler, "Managed Dependability in Interacting Systems," in Principles of Performance and Reliability Modeling and Evaluation: Essays in Honor of Kishor Trivedi on his 70th Birthday, L. Fiondella and A. Puliafito, Eds. Cham: Springer International Publishing, 2016, pp. 197–226.

### The 5G concept

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#### • Virtualization: NFV







P. E. Heegaard, B. E. Helvik, G. Nencioni, and J. Wäfler, "Managed Dependability in Interacting Systems," in *Principles of Performance and Reliability Modeling and Evaluation: Essays in Honor of Kishor Trivedi on his 70th Birthday*, L. Fiondella and A. Puliafito, Eds. Cham: Springer International Publishing, 2016, pp. 197–226.



## The 5G concept

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01100001010110

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#### • From C-RAN to Multi-RAT



R. Wang, H. Hu, and X. Yang, "Potentials and Challenges of C-RAN Supporting Multi-RATs Toward 5G Mobile Networks," IEEE Access, vol. 2, pp. 1187–1195, 2014.

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H. Zhang et al., "Network Slicing Based 5G and Future Mobile Networks: Mobility, Resource Management, and Challenges," IEEE Communications Magazine, vol. 55, no. 8, pp. 138–145, Aug. 2017. F. Z. Yousaf et al., "NFV and SDN - Key Technology Enablers for 5G Networks," IEEE Journal on Selected Areas in Communications, vol. 35, no. 11, pp. 2468–2478, Nov. 2017.

#### • Feeder automation and protection



• Smart Meters Acquisition and Load Control



#### • Distributed Generation Control



• Video Surveillance



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"5G Network Slicing - Enabling the Smart Grid." [Online]. Available: http://www-file.huawei.com/-/media/CORPORATE/PDF/News/5g-network-slicing-enabling-the-smart-grid.pdf H. V. K. Mendis, P. E. Heegaard, and K. Kralevska, "5G Network Slicing for Smart Distribution Grid Operations," in CIRED, 2019, p. 5. (SUBMITTED)

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### Risk and reliability in complex systems





P. E. Heegaard, B. E. Helvik, G. Nencioni, and J. Wäfler, "Managed Dependability in Interacting Systems," in *Principles of Performance and Reliability Modeling and Evaluation: Essays in* Honor of Kishor Trivedi on his 70th Birthday, L. Fiondella and A. Puliafito, Eds. Cham: Springer International Publishing, 2016, pp. 197–226.



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