5G-VINNI

(Horizon 2020 ICT-17 project)

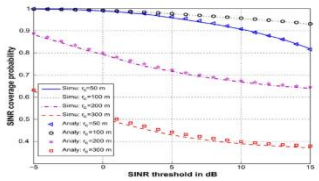
Pål Grønsund, Telenor Research

NKOM Frekvensforum, Lillesand, 19th Sept 2018

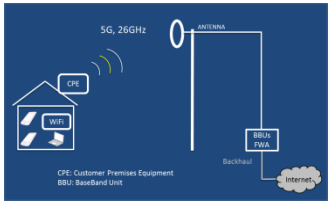
This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 815279.

Outline

5G-VINNI Project Overview



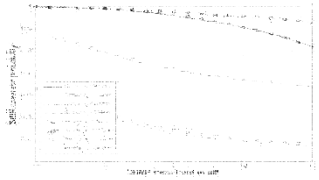
26 GHz characteristics for mobile communications



26 GHz Use Cases

Outline

5G-VINNI Project Overview

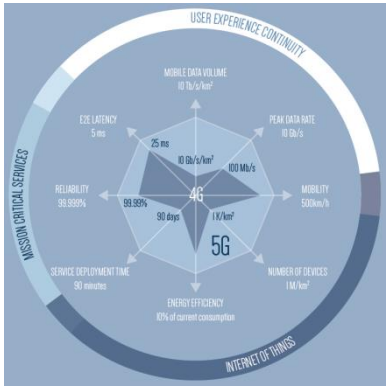


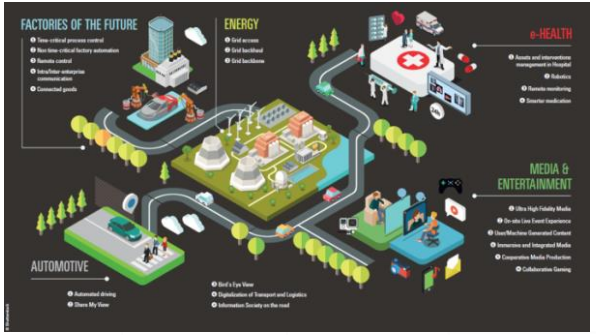
26 GHz characteristics for mobile communications

26 GHz Use Cases

5G-VINNI (**5G V**erticals **INN**ovation **I**nfrastructure)

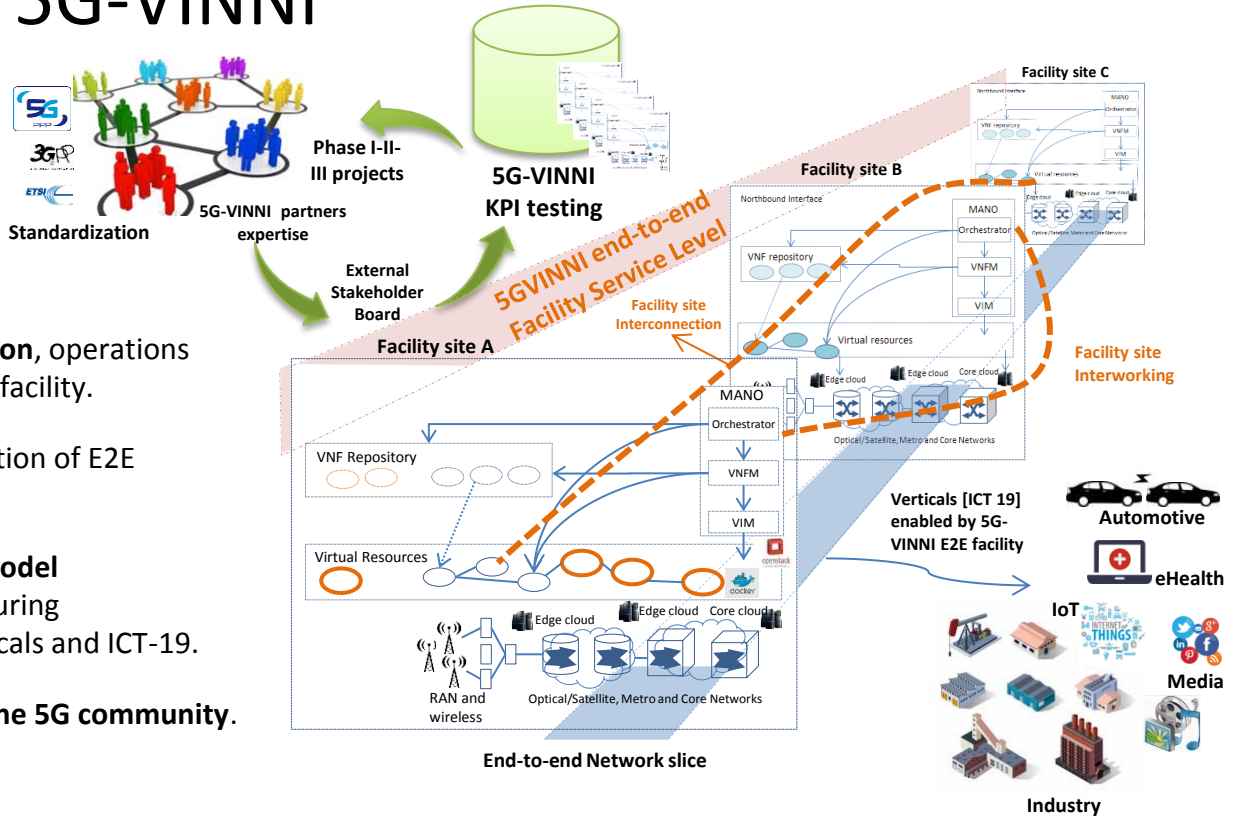
- Build an open large scale 5G End-to-End facility that can
  - demonstrate that key 5G network KPIs can be met
  - be validated, accessed and used by vertical industries (e.g. in ICT-19 projects) to test use cases and validate 5G KPIs.
- Duration: 3 years, budget: 19,998 M€
- Consortium: 23 partners (operators, vendors, academics, SMEs)
- External Stakeholder Board: Vertical industry





Key objectives of 5G-VINNI

1. Design an advanced and accessible 5G end to end facility for verticals and ICT-19.
2. Build several **interworking** sites of the 5G-VINNI end to end facility.
3. Provide user friendly **zero-touch orchestration**, operations and management systems for the 5G-VINNI facility.
4. **Validate the 5G KPIs** and support the execution of E2E trial of vertical use cases for ICT-19 projects.
5. Develop a viable **business and ecosystem model** to support the life of the 5G-VINNI facility during and beyond the span of the project for verticals and ICT-19.
6. **Demonstrate the value of 5G solutions to the 5G community**.



5G-VINNI Facility Sites

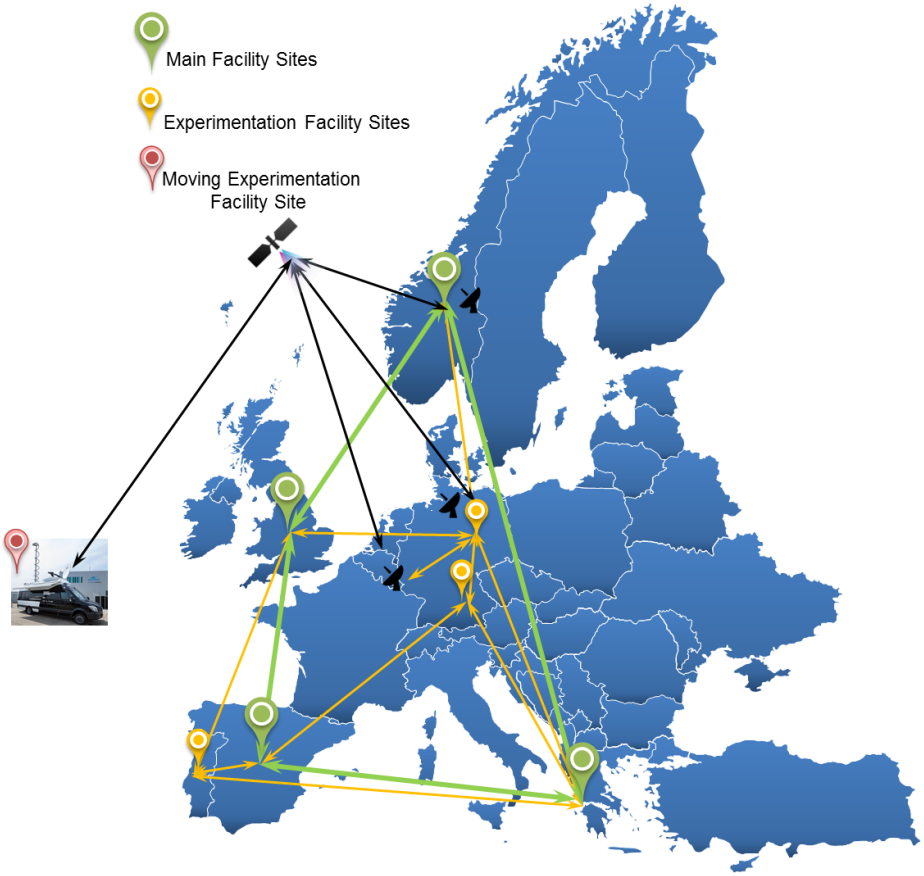
Main Facility sites: E2E 5G-VINNI facility that offers services to ICT-18-19-22 projects with well-defined Service Level Agreements.

- Norway (Oslo, Kongsberg)
- UK (Martlesham)
- Spain (Madrid)
- Greece (Patras)

Experimentation Facility sites: provide environments for advanced focused experimentation and testing possibilities on elements and combinations of elements of the E2E model.

- Portugal (Aveiro)
- Germany (Berlin)
- Germany (Munich)

Moving Experimentation Facility site: satellite connected vehicle.

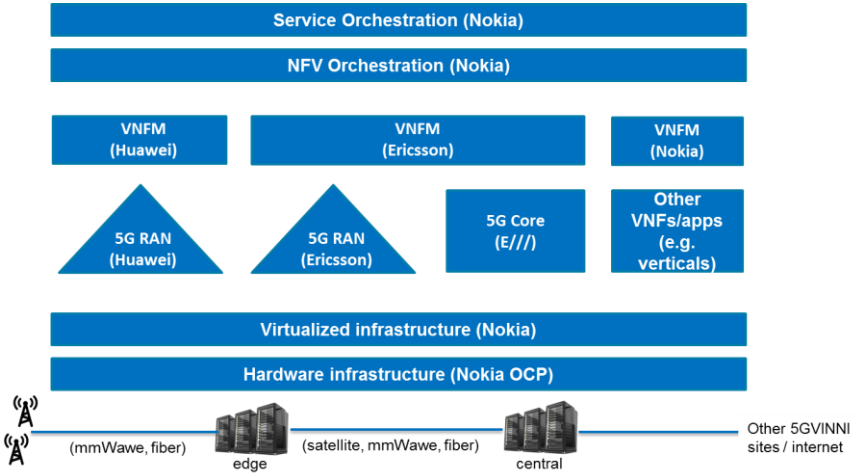


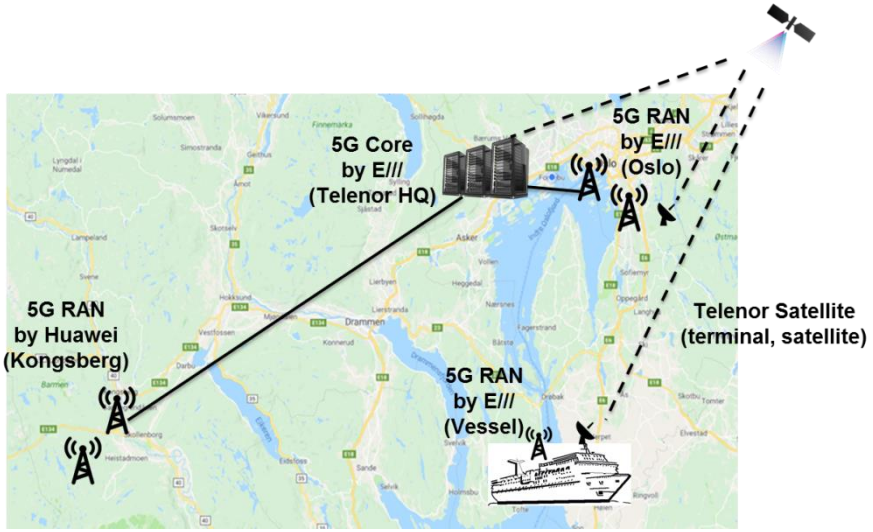
Capabilities in the Facility Sites

Capabilities	Main Facility sites	Experimentation Facility sites
5G NR	X	X
5G Core	X	X
NFV Infrastructure and Orchestration	X	X
Multi-Access Edge Computing (MEC)	X	X
Network Slicing	X	X
E2E Service Orchestration	X	
Interworking and interconnection among facility sites	X	
Testing framework	X	
Distributed Data Fabric Service	X	

Note: the experimentation facility sites will have advanced capabilities not specified in the table, please refer to the facility site summary slide.

Norway Facility site





Use Cases (work in progress):

- *Fixed Wireless Access* in 26 GHz, 3.5 GHz.
- *Public Safety*, e.g. with military considering AR/VR.
- *eHealth*, remote ultrasound control, doctor-to-doctor communications using hololens.
- *Factory of the future*: under investigation with factory facility in Norway.

5G-VINNI Facility Sites – Summary

Main Facility sites

Norway (Oslo, Kongsberg)

- Slicing (eMMB, URLLC, mMTC)
- E2E Service Orchestration (Nokia)
- NFVI (OpenStack) and MANO (Nokia)
- MEC (Nokia)
- Four 5G gNBs (Ericsson, Huawei)
  - 3.5GHz, 90MHz BW
  - 26GHz, 800MHz BW
- 5G Core (Ericsson)
- 3GPP compliance
  - Rel'15 in 2019, Rel'16 in 2021
  - NSA in 2019, SA in 2021
- Satellite backhaul option (GEO)

UK (Martlesham)

- Slicing (eMMB, URLLC, mMTC)
- Service Orchestration (Nokia)
- NFV MANO, NFVI and vEMS (Samsung)
- MEC
- 5G RAN incl. 3.5 and 26GHz (Samsung)
- 5G Core (Samsung)
- 3GPP compliance
  - Rel'15 in 2019, Rel'16 in 2021
  - NSA in 2019, SA in 2021

Spain (Leganes)

- Slicing (OSM extension)
- Service Orchestration (OSM NBI)
- NFV MANO (OSM) and NFVI (OpenStack)
- SDN (ODL/ONOS)
- Support for micro-VNFs
- 5G RAN (SDR), low frequencies and 30-300GHz
- Advanced monitoring and data-driven management
- Edge computing (MEC and non-MEC)
- 5G Core (possibly SBA-based)

Greece (Patras)

- Slicing (eMMB, URLLC, mMTC, via OSM)
- Service Orchestration (via OSM NBI services)
- NFV MANO (OSM) and NFVI (OpenStack)+DPDK
- 5G RAN open source radio (Lime, SRS)-700-800MHz, 3.5.-3.8GHz
- 5G Core (Open5GCore)
- NB-IoT, LTE-M (FhG NB-IOT core)
- mmWave backhaul (Intracom)
- GEANT connectivity
- MEC

Experimentation Facility sites

Portugal (Aveiro)

- Service Orchestration (Alticelabs)
- NG-PON2-based 5G front/backhaul (Alticelabs)
- NFVI (OpenStack)
- SDN (ODL)
- Cloud RAN
- MEC

Germany (Berlin)

- 5G RAN prototype(s)
- 5G Core (Open5GCore)
- Edge cloud/e2e Orchestration (OpenBaton)
- mmWave backhaul
- Interconnection with remote islands in Betzdorf and Tokyo
- Large scale events, Nomadic networks, Disaster Relief

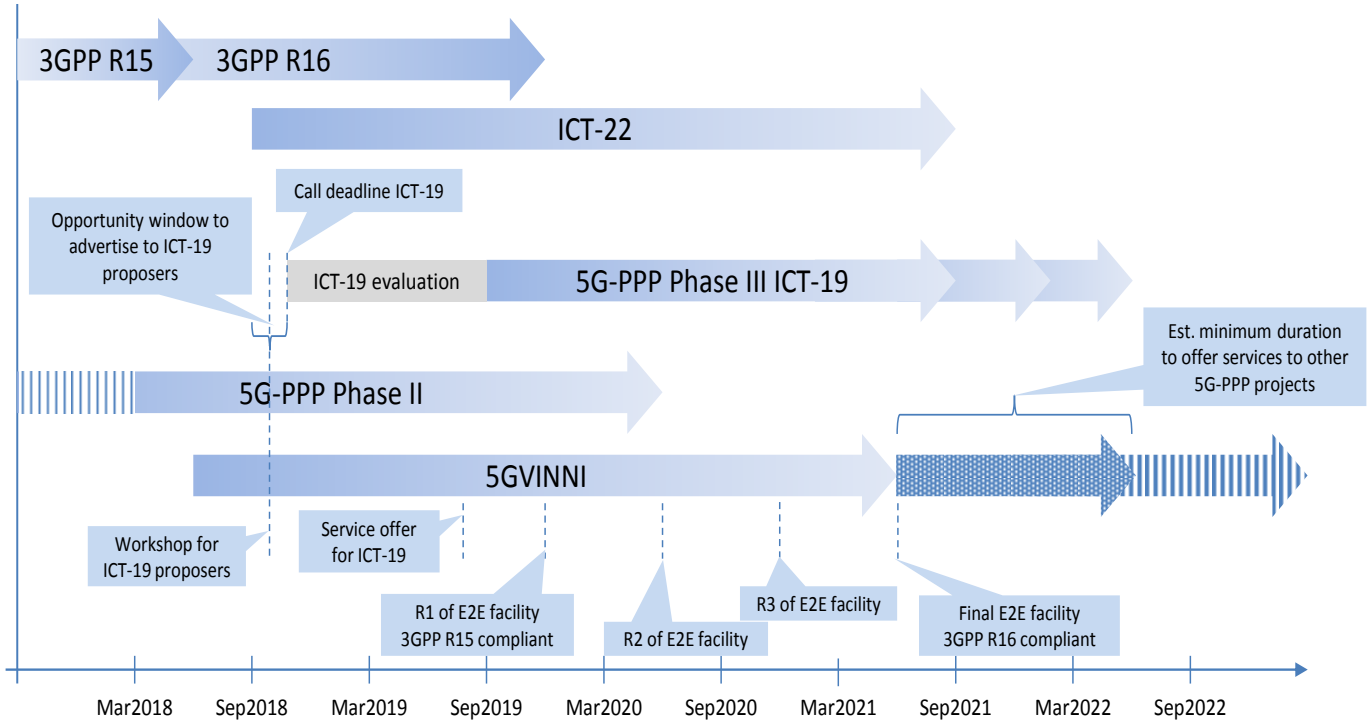
Germany (Munich)

- 5G NR SA RAN (Huawei) 3.5 GHz
- 5G Core (Huawei)
- MANO and NFVI (Huawei)
- SDN (Floodlight)
- V2I, V2P
- MEC, Edge Computing
- URLLC targeting Rel16/17
- Sensor fusion enabled by 5G

Luxembourg (Satellite Connected Vehicle)

- GEO/MEO satellites (SES)
- C/X/Ku/Ka-band (SES)
- Satellite teleport (SES)
- Satellite backhauling (SES)
- Satellite 5G testbed node with SDN/NFV/MEC (SES)
- Satellite interconnection with Berlin Facility site (SES)
- eMBB, mMTC use cases (SES)

Global Timing



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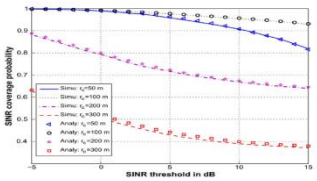


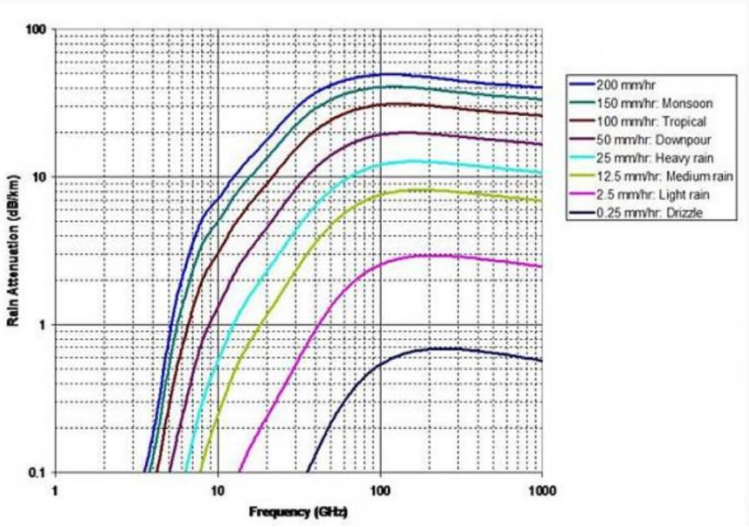
26 GHz characteristics for mobile communications

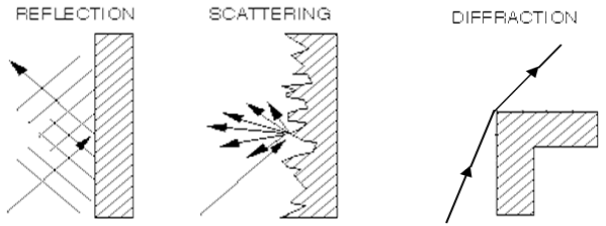
26 GHz Use Cases

Some characteristics of 26 GHz for mobile communications

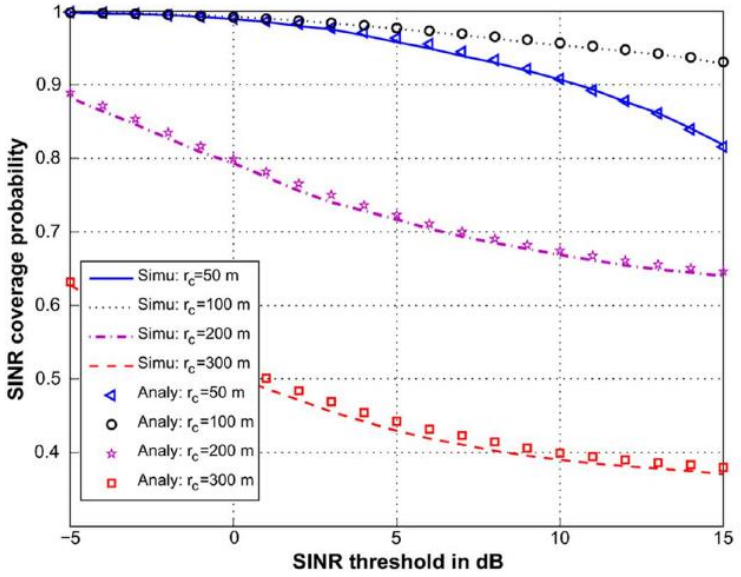
- Propagation effects
  - Rain attenuation
  - Material penetration
  - Reflection and scattering
  - Diffraction effect more similar to visible light

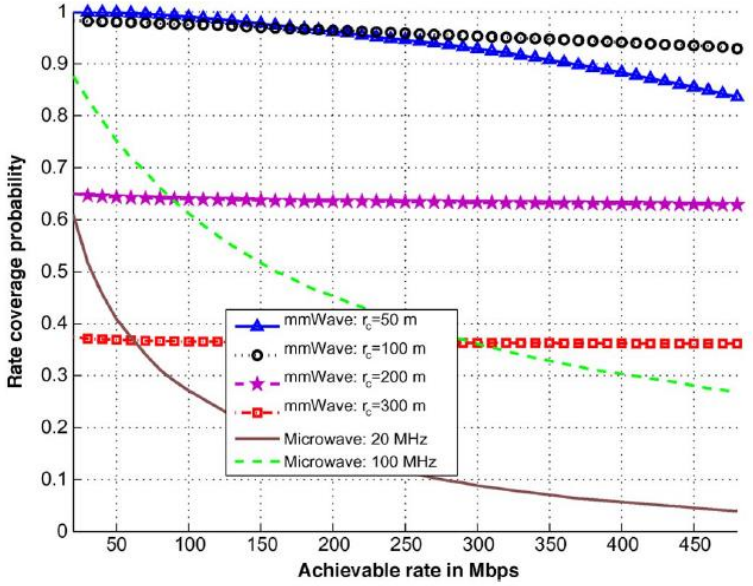
- Impact on mobile communications
  - Good connectivity will usually require Line of Sight
  - Indoor users less likely to be covered by outdoor base stations
  - High gain antenna needed at both base station and user terminals
  - Body attenuation is a problem





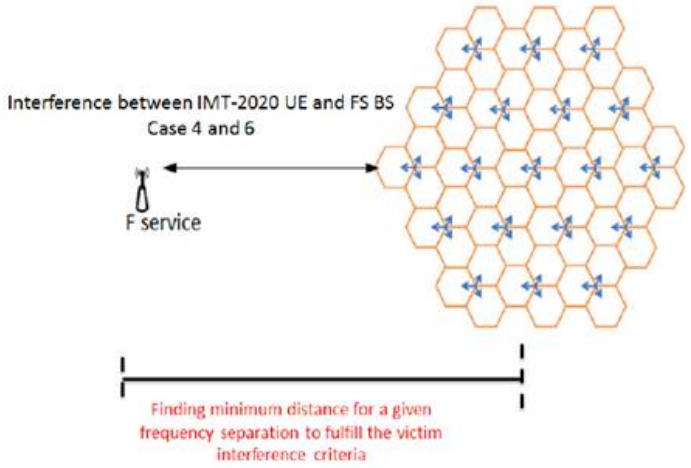
Optimal cell size and need for line of sight





[Tianyang Bai and Robert W. Heath, "Coverage and Rate Analysis for Millimeter-Wave Cellular Networks", IEEE Trans. Wireless Commun., Feb. 2015, pp. 1100-1114.]

Point-to-point wireless systems interference in co-and adjacent channels must be considered



[W. A. Hassan, H. S. Jo and A. R. Tharek, "The Feasibility of Coexistence Between 5G and Existing Services in the IMT-2020 Candidate Bands in Malaysia," IEEE Access, vol. 5, pp. 14867-14888, 2017.]

	Minimum separation distance [km]			
	Co-channel		Adjacent channel	
	Rural	Urban	Rural	Urban
Case 1: 5G BS -> FS (MCL)	1082*	76	362 @ ACIR = 10 dB 109 @ ACIR = 20 dB 37 @ ACIR = 30 dB 12 @ ACIR = 40 dB	24.6 @ ACIR = 10 dB 7.9 @ ACIR = 20 dB 2.7 @ ACIR = 30 dB 0.8 @ ACIR = 40 dB
Case 2: FS -> 5G BS (MCL)	7.07	0.624	2.28 @ ACIR = 10 dB 0.76 @ ACIR = 20 dB 0.23 @ ACIR = 30 dB 0.07 @ ACIR = 40 dB	0.194 @ ACIR = 10 dB 0.06 @ ACIR = 20 dB 0.021 @ ACIR = 30 dB 0.0069 @ ACIR = 40 dB
Case 3: 5G UE -> FS (MCL)	26.69	27.16	8.46 @ ACIR = 10 dB 2.8 @ ACIR = 20 dB 1.1 @ ACIR = 30 dB 0.36 @ ACIR = 40 dB	8.64 @ ACIR = 10 dB 2.83 @ ACIR = 20 dB 0.96 @ ACIR = 30 dB 0.38 @ ACIR = 40 dB
Case 4: 5G UE -> FS (MC)	34.3	38.8	10.7 @ ACIR = 10 dB 3.3 @ ACIR = 20 dB 0.2 @ ACIR = 30 dB 0.02 @ ACIR = 40 dB	12.3 @ ACIR = 10 dB 3.9 @ ACIR = 20 dB 1.2 @ ACIR = 30 dB 0.4 @ ACIR = 40 dB
Case 5: FS -> 5G UE (MCL)	0.23	0.18	0.07 @ ACIR = 10 dB 0.027 @ ACIR = 20 dB 0.008 @ ACIR = 30 dB 0.003 @ ACIR = 40 dB	0.059 @ ACIR = 10 dB 0.019 @ ACIR = 20 dB 0.006 @ ACIR = 30 dB 0.0019 @ ACIR = 40 dB
Case 6: FS -> 5G UE (MC)	7.01	7.85	1.93 @ ACIR = 10 dB 0.23 @ ACIR = 20 dB 0.1 @ ACIR = 30 dB 0.03 @ ACIR = 40 dB	2.53 @ ACIR = 10 dB 0.7 @ ACIR = 20 dB 0.2 @ ACIR = 30 dB 0.02 @ ACIR = 40 dB

* Flat earth model used, indicates that harmful interference will occur over long distances.

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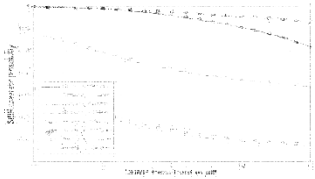
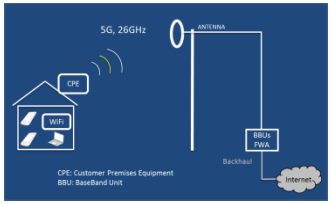
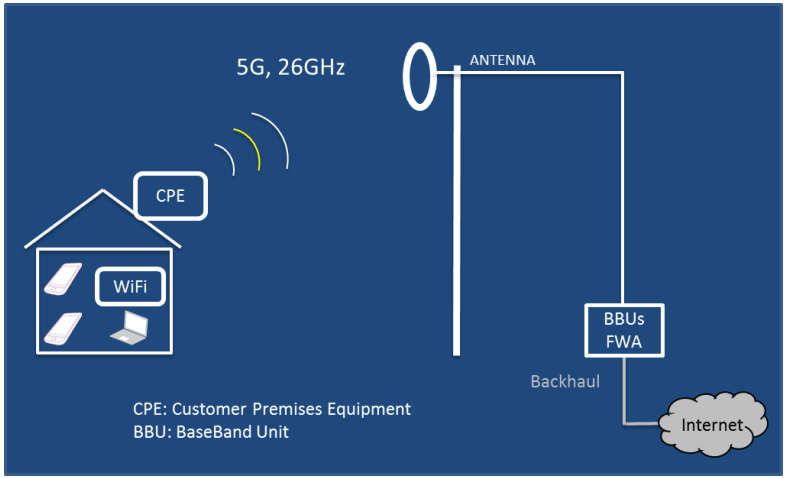


26 GHz characteristics for mobile communication

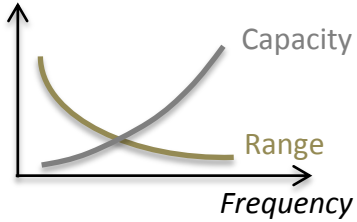


26 GHz Use Cases

Fixed Wireles Access in 26 GHz



Frequency matters



Technology matters

In 5G-VINNI we plan to test advanced 5G systems in 26 GHz to validate the 5G KPIs.

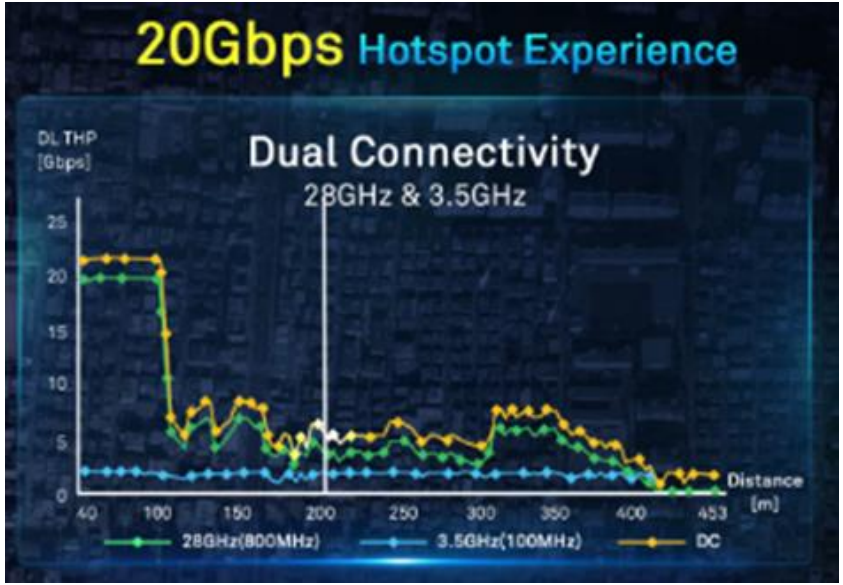
Fixed Wireles Access in 26 GHz – early results indicates immature solutions

Distance [m]	DL Throughput [Mb/s]	UL Throughput [Mb/s]
300 (LOS)	**1563.5**	**1560.2**
300 (NLOS)	84.3	74.9
350 (LOS)	**836.7**	**825.6**
350 (NLOS)	188.2	193.4
450 (LOS)	**1561.1**	**1557.5**
450, 570 (NLOS)	0	0
700 (LOS)	**1248.0**	**1226.0**

- Measured outdoor-to-outdoor data rates at 28 GHz
- 2x2 MIMO
- 50:50 uplink /downlink TDD split
- 17 dBi antenna gain
- 32 dBm transmit power per antenna
- channel bandwidth of 800 MHz

[D. Soldani, P. Airas, T. Hoglund, H. Rasanen and D. Debrecht, "5G to the Home," 2017 IEEE 85th Vehicular Technology Conference (VTC Spring), Sydney, NSW, 2017, pp. 1-5.]

Fixed Wireles Access in 26 GHz – maturing systems show better performance



[Huawei, MWC, Feb 2018]

Outdoor drive test, BS 64T64R, CPE 4T8R

Other use cases of interest for 26 GHz

Indoor Pico Base Station is well suited for providing capacity in open indoor spaces

- Measurements in small scale stadium seating area show that human blockage loss due to diffraction models is pessimistic in indoor stadiums since scattering and reflections of signals from neighboring human bodies can provide strong signal paths at millimeter wave bands.

  [M. N. Islam, S. Subramanian, A. Partyka and A. Sampath, "Coverage and capacity of 28 GHz band in indoor stadiums," IEEE Wireless Communications and Networking Conference, Doha, 2016, pp. 1-7.]

- Shopping malls - open areas vs. areas with small shops and other objects (e.g. walls, furnitures)

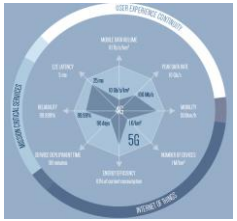
Outdoor small cells – for areas with high capacity demand.

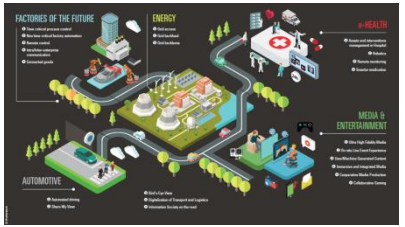
Capacity enhancement using existing macro grid – for offloading macro network and to offer extremely high data-rates in some spots.

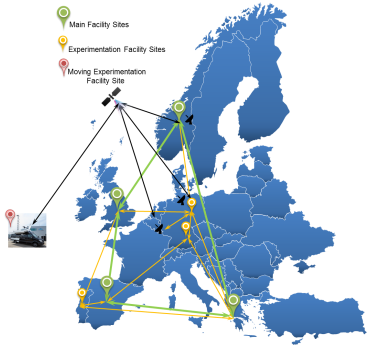
Positioning – e.g. automated driving

In summary

5G-VINNI will build an open large scale 5G End-to-End facility that can to validate 5G KPIs and vertical industry use cases.

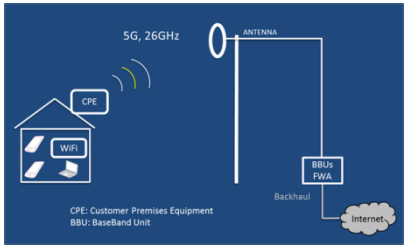






The facility site in Norway will initially be deployed in Oslo and Kongsberg with 5G solutions from Nokia, Ericsson, Huawei and Cisco.

Frequency bands identified for 5G including 3.5 GHz and 26 GHz will be used considering a variety of use cases.



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Supplementary

Contact

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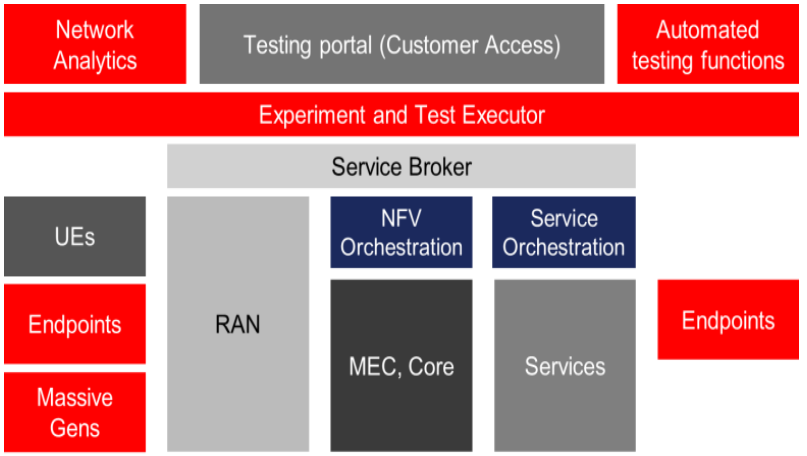
This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 815279.

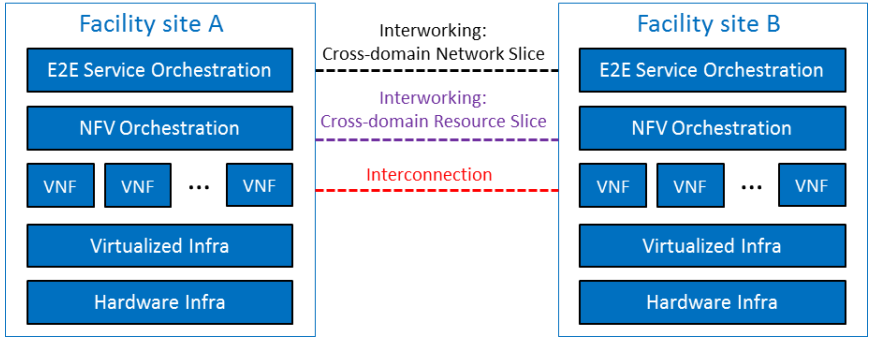
5G-VINNI Test Framework

- Availability of a corpus of test cases to be used as is or as templates for customization
- Availability of a testing portal that allows:
  - Creation and customization of individual test cases
  - Management of testing campaigns (including overnight testing)
  - Results processing and analytics (analytics expected by 2020/2021)
- Easy integration of third parties components and systems under test via open SDK
- Consulting services for testing and experimentation

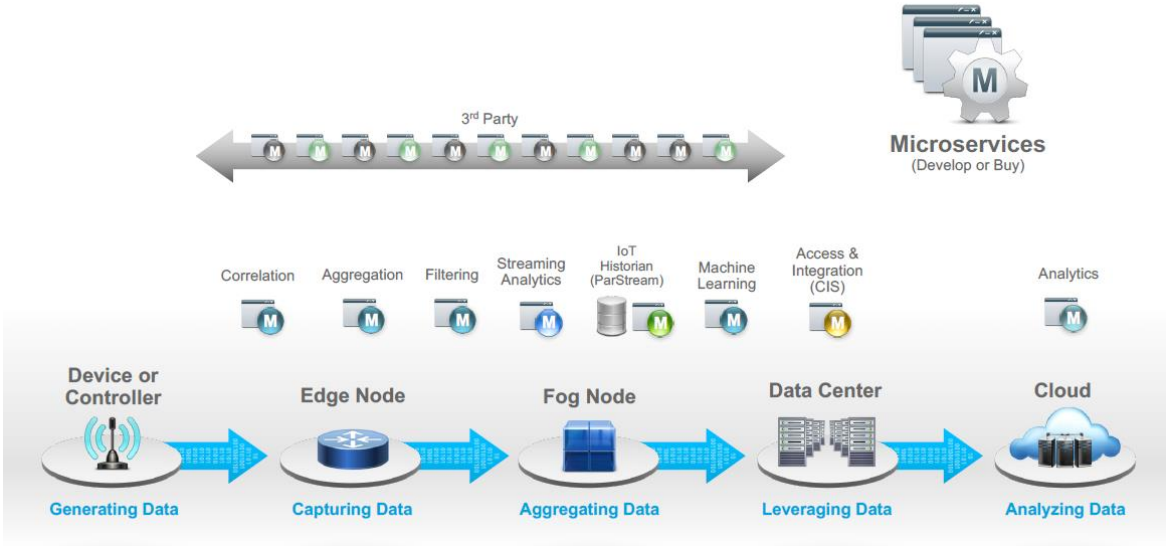


Interworking and Interconnection among Main Facility sites

- Interconnection among facility sites:
  - Connectivity between facility sites.
- Interworking among facility sites:
  - Network Slice crossing different facility sites (domains)
  - Potentially also Resource Slice crossing different facility sites (domains)
- Interworking implies interconnection.
- Management and Orchestration of cross-domain services, resources and SLAs will enable and support interconnection and interworking.
- 5G-VINNI is open to interwork and interconnect with other non-5G-VINNI facilities.
- Detailed specification and SLAs will be defined.
- (some facility sites are connected to GÉANT)



Distributed Data Fabric Service



- Service to extract, compute/transform and move data across the distributed network facility (edge, core, …).
- Micro-services that make up the data fabric service are distributed throughout the infrastructure.
- Orchestrated and provided as a service, particular relevance for IoT type vertical industry use cases.

Partners of 5G-VINNI

Partners are carefully selected to fulfil the objectives of 5G-VINNI for the ICT-17 call

External Stakeholder Board for vertical industry and other institutions important for vertical use cases is established, e.g.

- Logistics
- Shipping
- Transportation
- Media & entertainment
- AR / VR
- Automotive
- Public safety / PPDR

Partners		
Operators	Telenor ASA (TnResearch, TnNorway, TnSatellite)	Norway
	BT	UK
	Telefonica	Spain
	SES	Luxembourg
Industry	Huawei	Norway & Germany
	Ericsson	Norway
	Nokia	Finland / Norway
	Samsung	UK
	Intracom	Greece
	Keysight	Denmark
	Cisco	Norway
	Alticelabs	Portugal
	Engineering	Italy
Academia	AUEB	Greece
	UC3M	Spain
	Simula	Norway
	Uni. Patras	Greece
	Fraunhofer FOKUS	Germany
SME	EANTC	Germany
	Limemicro	UK
	SRS	IR
Ad min	Eurescom	Germany