The ONE5G approach towards the challenges of **multi-service** operation in 5G systems

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NOKIA Bell Labs

5G PPP
The 5G Infrastructure Public Private Partnership

Agenda

- Ambition of this presentation
- Background and objectives
- 5G NR needs vs. ONE5G innovations
- Landing zones
- The scenarios
- The multi-service aspect
- Going beyond radio KPIs (adoption of Key Quality Indicators, KQIs), KQI categories
- Technical areas and some exemplary research items
- Proof of Concepts

Ambition of this presentation

- to introduce to you the project ONE5G
- to offer you a glimpse into the wide area ONE5G is diving into
- to lure you
  - to visit our homepage: one5g.eu
  - to read our deliverables: one5g.eu/documents/
  - to visit us at EuCNC: special session + booth
  - to visit us at Globecom: workshop

Background and objectives

- 14 partners, 2 years, H2020 phase 2, follow-up of FANTASTIC-5G (plus members from mmMAGIC)
- ONE5G = E2E-aware optimizations and advancements for the network edge of 5G new radio
  - E2E → adoption of KQIs (Key Quality Indicators)
  - optimizations and advancements → move 5G towards 5G-advanced
  - network edge → although we are E2E-aware focus is still the RAN, network elements beyond the RAN to be accounted for via abstractions/models

ONE5G

Background and objectives

- 5G extensions (cost and performance) both for „Megacities“ and „Underserved Areas“
- Identification of the cost driving elements for roll-out and operation, account for areas with constrained circumstances
- Advanced link technologies for multi-service operation
- Highly generic performance optimization schemes for deployment and operation (E2E)

minimize digital divide, enable multi-service, move 5G towards 5G-advanced

5G NR needs vs. ONE5G innovations

Needs and features in the 5G era, beyond Rel. 15 and addressed by ONE5G

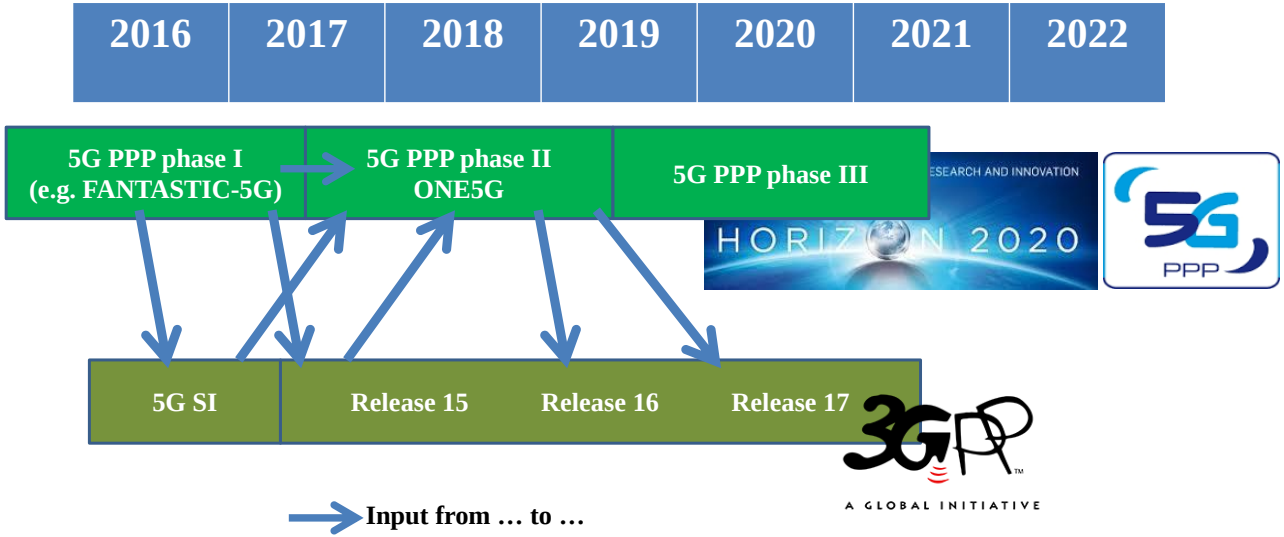
- **Multiplicity of services**
  (eMBB, mMTC, URLLC, etc.)
  Various vertical sectors
- **Verticals requirements**
  (automotive, factories, smart cities, etc.)
- **Multiple environments**
  ("Megacities", "Underserved Areas")
  with high variability of traffic demand
- **Heterogeneous technologies**
  (Network Nodes, Devices, Spectrum)

ONE5G innovations

- **generic and flexible air interface**
  - Tuning 5G to meet requirements in multi-service and multi-environment situations
  - Automatically accommodating to scenario-dependent requirements in a cost-efficient manner
- **PHY, MAC advancements**
  - Link enhancements (access schemes, signaling, etc.)
  - Massive MIMO, multi-antenna enhancements, scalable antenna systems
  - Advanced link management based on multi-cell processing
- **Multi-service and multi-environment optimization**
  - Optimized multi-link management for improved E2E performance
  - Network and user-experienced E2E performance optimization and context awareness
- **Building consensus in 3GPP on next phases for 5G, beyond Rel.15**
  - Forward compatibility, Future proofness
  - Provision of the 5G Advanced (pro) framework
- **Validation**
  - Analysis, simulation, prototyping and PoC of new 5G Advanced (pro) technologies
- **Dissemination and IPR**
  - Scientific papers/presentations and patents

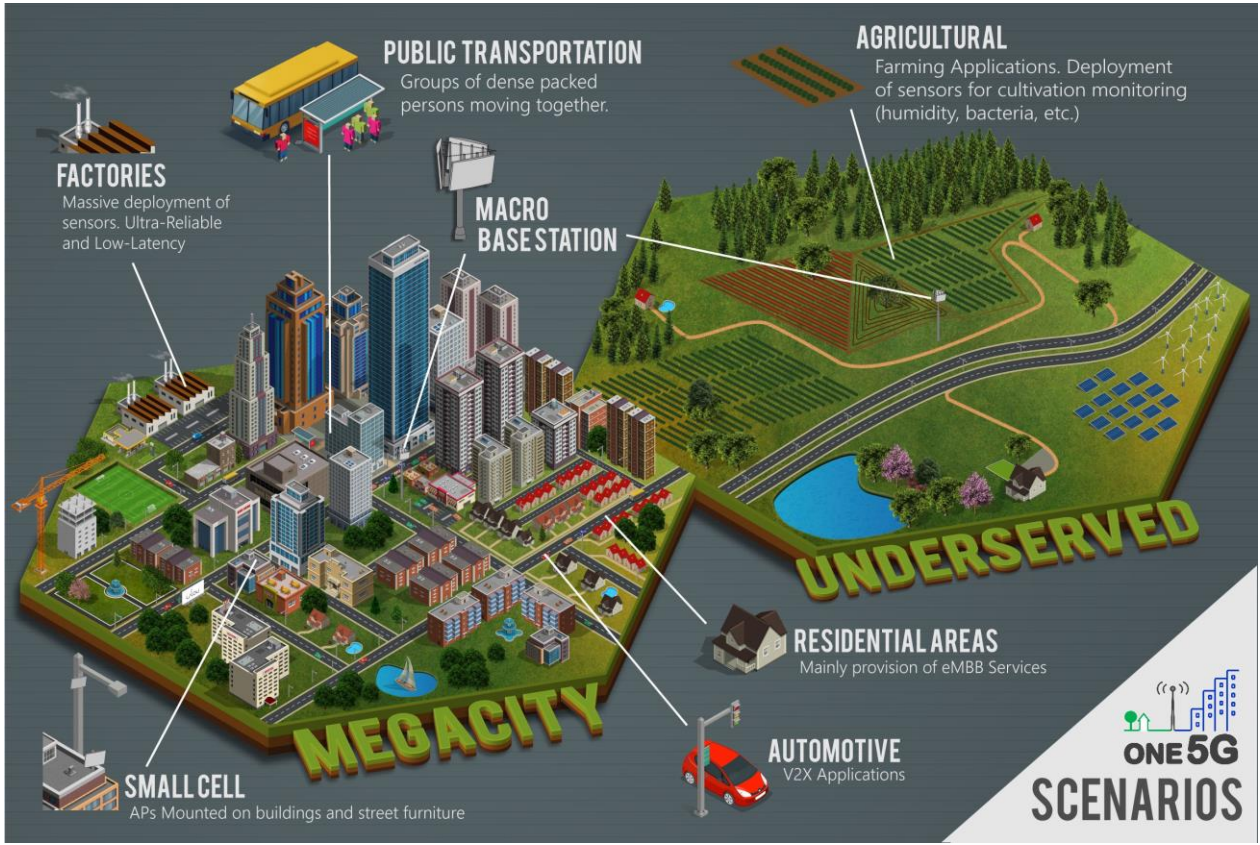
Landing zones

- Moving 5G (release 15) towards 5Gadvanced (release 16 and 17)



The scenarios

- Key differences
  - Building structures/densities
  - Open spaces
  - Density of users/devices
  - Mobility
  - Cost constraints
  - Access to backhaul/power
  - Mix of use cases
  - RAN architecture



The multi-service aspect

- ONE5G is not focussing on
  - a single/few verticals
  - a single service category

	No.	Use Case	Vertical business	Level of standards maturity w.r.t. 3GPP/other	Service categories	Scenario
Core use cases	1	Assisted, cooperative and tele-operated driving (between vehicles, and between them and infrastructure)	Automotive	High (TR 22.886)	all	Megacities, Underserved Areas
	2	Time-critical factory processes and logistics optimisation (industry and smart airports)	Factories, Transport and Logistics	High (TS 22.261)	all	Megacities
	3	Non time-critical processes and logistics (factories and smart cities)	Smart Cities and Energy	High (TR 45.820 and TR 38.913)	mMTC	Megacities, Underserved Areas
	4	Long range connectivity in remote areas with smart farming application	Agriculture	High (TR 38.913)	eMBB, mMTC	Underserved Areas
	5	Outdoor hotspots and smart offices with AR/VR and media applications	Media, Entertainment and eOffice	High (TR 38.913, TS 22.261, ...)	eMBB	Megacities
	6	Live Event Experience	Media, Entertainment and eOffice	High (TS 23.246, TS 26.346, ...)	eMBB	Megacities, Underserved Areas
Associated use cases	7	Health/wellness monitoring	eHealth and Wellness	Low	mMTC, UR(LL)C	Megacities, Underserved Areas
	8	Smart grid, connected lighting and energy infrastructure	Smart Cities and Energy	Med (eg: TR 45.820 and TR 38.913)	mMTC	Megacities, Underserved Areas
	9	Ad-hoc airborne platforms for disasters and emergencies	Disasters and Public Safety	High (Study Item on NR to support non-terrestrial networks)	eMBB/mMTC	Megacities, Underserved Areas

Going beyond radio KPIs (adoption of Key Quality Indicators, KQIs), KQI categories

- **Network Availability:** The probability of success that network functions can be performed over a specified period.
- **Network Accessibility:** The probability that the user requesting a service to the network receives the proceed to request within specified conditions.
- **Service Accessibility**: The ability of a service to be obtained, when requested by the user, within specified targets.
- **Service Integrity:** The degree to which a service is provided with acceptable quality, i.e. without major impairments, once obtained.
- **Service Retainability:** The probability that a service, once obtained, will continue to be provided under given conditions, i.e. without interruptions.

introduced by ETSI [102.250], profiled by 3GPP [32.862, 26.944]

eMBB already well defined, mMTC and URLLC still rather open

Service specific KQIs for eMBB

KQI category	File transfer	Video Streaming	Web-browsing
Service accessibility (KQI-A)	Initial File Transfer Delay (s)	Video Streaming Start delay (s)	Page Response Delay (s)
Service Integrity (KQI-I)	File Transfer avg throughput (Mbps) File Transfer delay (s)	Video Bit Rate (Mbps): Min/Average/Max (Assumes Adaptive Bit Rate)	Avg Page Throughput (Mbps) Page Download Time (s)
Service Retainability (KQI-R)	File Transfer Cut off ratio (-)	Video Streaming Stall: • Frequency (-) • Number (-) • Time (s) Streaming cut off ratio (-)	Page Transfer Cut-off Ratio (-)

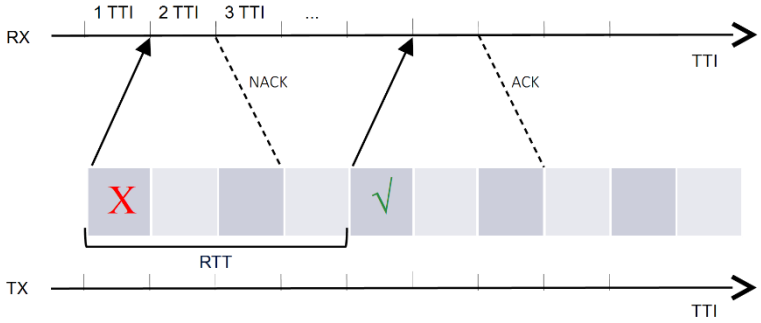
Technical areas

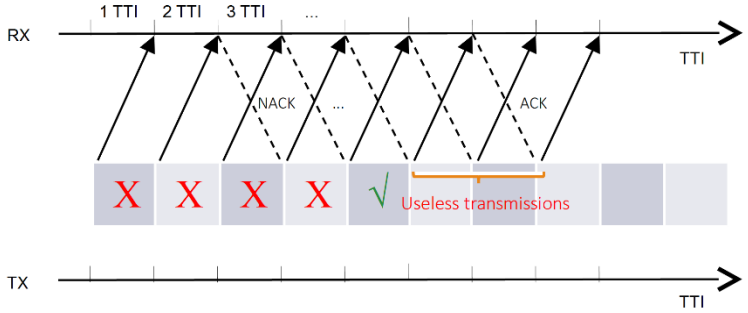
- multi-service access solutions: grant-free access, massive access, NOMA, HARQ enhancements
- enablers for practical implementation of mMIMO: low complexity/energy consumption implementations, optimized array shapes, hybrid designs, robust algorithms, mMIMO for wireless backhaul
- advanced pilot and feedback design: efficient CSI acquisition and feedback compression, explicit CSI knowledge, time domain feedback
- interference coord. and avoidance: grouping and node assignment, cross-link interference management
- Optimized RRC state handling and DRX

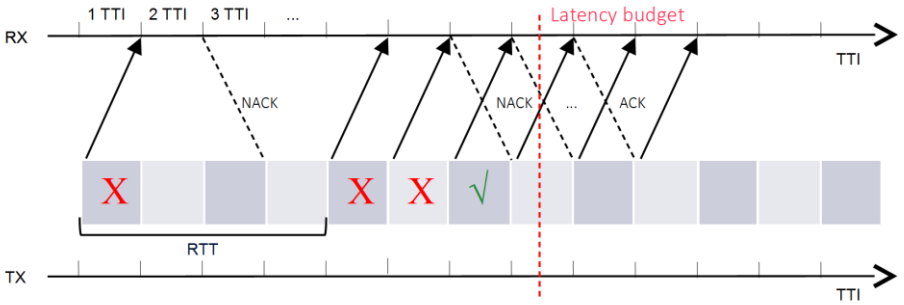
more details to be found in the project deliverables (one5g.eu/documents/) and publications

HARQ enhancments – ACK/NACK based vs. Blind vs. hybrid

- Top right: standard ACK/NACK based, efficient but takes time
- Bottom left: blind, quick but innefficient
- Bottom right: hybrid, start with standard ACK/NACK based until given deadline, then fire blindly eventually.

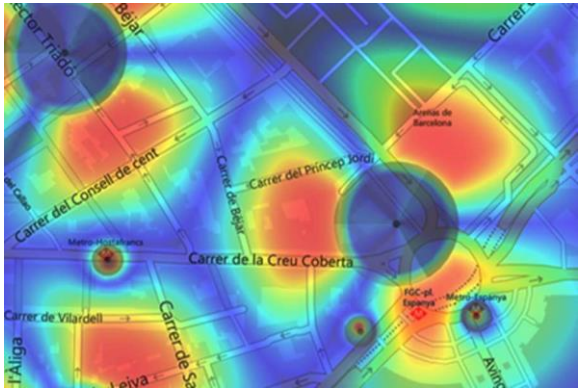


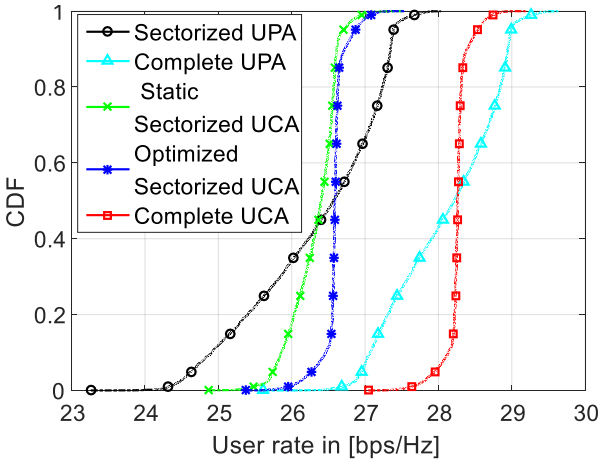


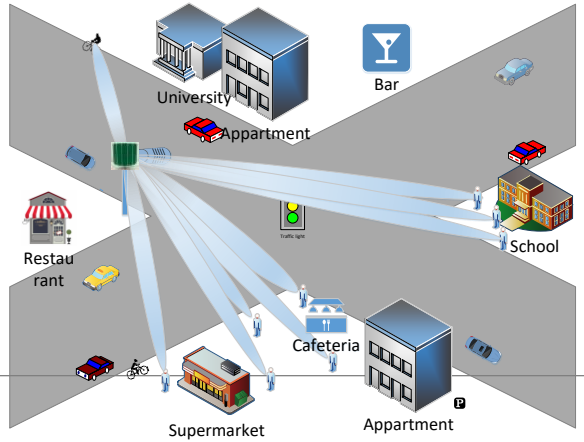


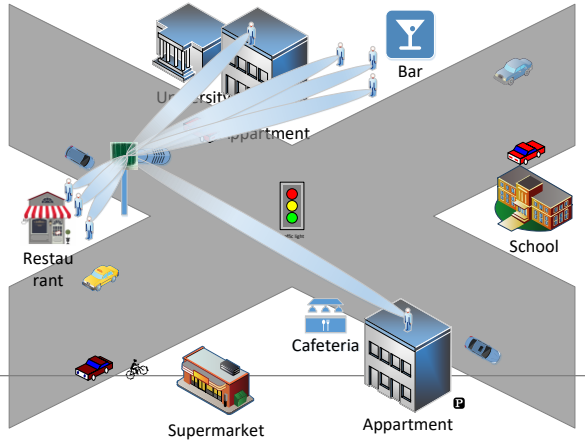
UPA (uniform planar array) vs. UCA (uniform circular array); static vs. adaptive pannels

- Top left: wideband SNR static UPA
- Top right: spectral efficiency
  UPA vs. UCA
- Bottom: adaptive panels, day-time vs. night-time









Optimized RRC state handling

		UE moves to / remains in RRC CONNECTED	UE moves to / remains in RRC INACTIVE	UE moves to / remains in RRC IDLE
UE in RRC CONNECTED	Data activity	High Activity UE Power Available Low/medium CP Network Load	Low Activity UE Power Restriction High Network CP Load	(Not relevant)
	No data activity	Known high activity profile UE Power Available Low/medium CP Network Load Low mobility state	UE Power Restriction High Network Load Low/Medium mobility state	Known very low and sporadic activity High mobility state
UE in RRC INACTIVE	Data activity	Data amount cannot be transferred without state transition	Data amount can be transferred without data transition Infrequent RNAU	(Not relevant)
	No data activity	(Not relevant)	Known activity profile Low/medium CP Network Load	Known very low/ sporadic activity UE Power restrict. High freq. of RNAU
UE in RRC IDLE	Data activity	Always	(Not feasible)	(Not relevant)
	No data activity	(Not relevant)	(Not feasible)	Always

Technical areas and some exemplary research items

- Multi-service RRM optimization: advanced QoE management (SDAP layer, mapping of QoS flows to DRBs), enhancements for multi-service resource allocation (MAC layer, pre-emptive scheduling)
- Multi-link/multi-node connectivity: data duplication/data aggregation, UL/DL decoupling, cell association
- Dynamic spectrum aggregation: unlicensed access, licensed/unlicensed band aggregation
- Mobility optimization, fast agile load balancing: QoE-based traffic steering, use of context information for load balancing, mobility managment accounting for the availability of computing resources (MEC-aware connectivity)

more details to be found in the project deliverables (one5g.eu/documents/) and publications

Enhancements for eMBB traffic when suffered pre-emption

HARQ scheme	Description	UE feedback
#1	Baseline: Upon reception of Nack, the full TB is retransmitted.	Single-bit ACK/NACK
#2	Partial retransmission: if the TB was subject to preemption, only the damaged part of the TB is retransmitted. Only if a second NACK is received for the same HARQ process is the full TB retransmitted again.	Single-bit ACK/NACK
#3	Only the CBs with NACK feedback are retransmitted. This is valid independently on whether the TB was subject to pre-emptive scheduling, or not.	CB-based ACK/NACK (multi-bit feedback)
#4	If the first TB transmission was subject to preemption, only the damaged parts of the CBs having received a corresponding NACK for is retransmitted. If full TB is not correctly decoded after the second HARQ transmission, the full TB is retransmitted again. If the first TB transmission was not subject to pre-emption, HARQ scheme #3 is applied.	CB-based ACK/NACK (multi-bit feedback)

Multi-connectivity options

Multi-connectivity

Inter-frequency

Carrier aggregation (intra-site)

Multi connectivity (inter-site)

Intra-frequency

Intra-site JT/DPS-CoMP

Inter-site Multi-Flow

Data split vs Data duplication

- Throughput enhancement
- Cell-edge throughput enhancement
- Ultra-low latency and high reliability
- Connection robustness

Proof of Concepts (PoCs)

Ambition: inclusion of selected technology components into existing testbeds

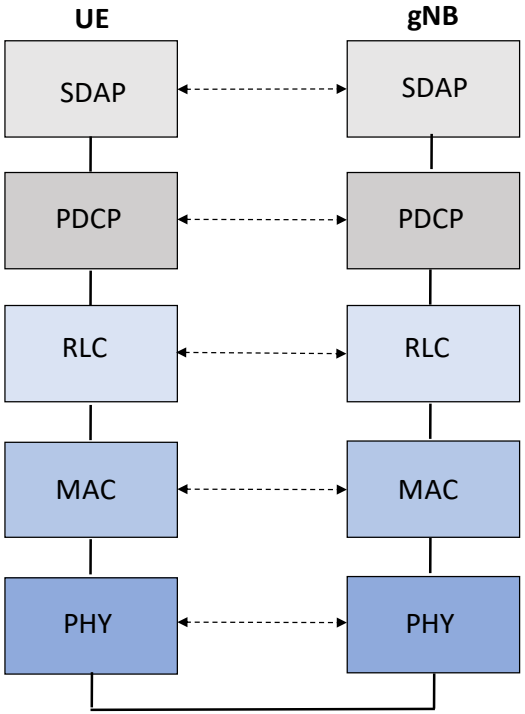
1. performance optimization techniques („cell-less“ design) - URLLC
   - e.g. dynamic multi-link/multi-node connectivity, macro-diversity
2. Multi-service coexistence – eMBB + mMTC
   - e.g. multi-link/-band service aggregation, context aware RRM, load balancing
3. mMIMO – eMBB
   - e.g. array design, sector and beam management, enhanced CSI acquisition
4. networks for agricultural use cases – mMTC + eMBB
   - e.g. slice management
5. Automotive – URLLC
   - e.g. robust synchronization, enhancements for high mobility and high reliability

visit us at EuCNC 2018 in 2 weeks (booth + special session)

Thanks!

Questions?

3GPP baseline – protocol stack



Mapping of QoS flow to DRB, marking of QoS flow ID, QoE manager

Numbering, compression, Security (ciphering and integrity protection), reordering, routing or packet-duplication

Segmentation, duplicate detection, RLC SDU discard, RLC re-establishment, Protocol error detection, retransmission (ARQ)

Mapping between logical channels and transport channels, scheduling and priority handling, transport format selection, hybrid ARQ (HARQ)

New flexible NR PHY design, flexible frame structure, configurable PHY numerology, mMIMO, beamforming, etc.

3GPP baseline – QoS architecture