

COSMOS Project Introduction

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COSMOS: Project Team



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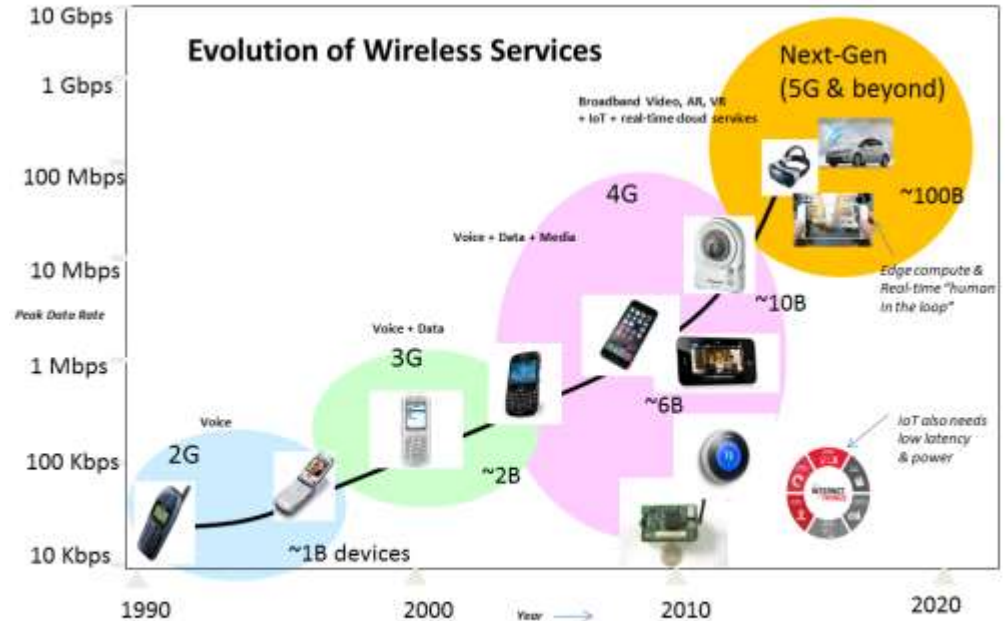
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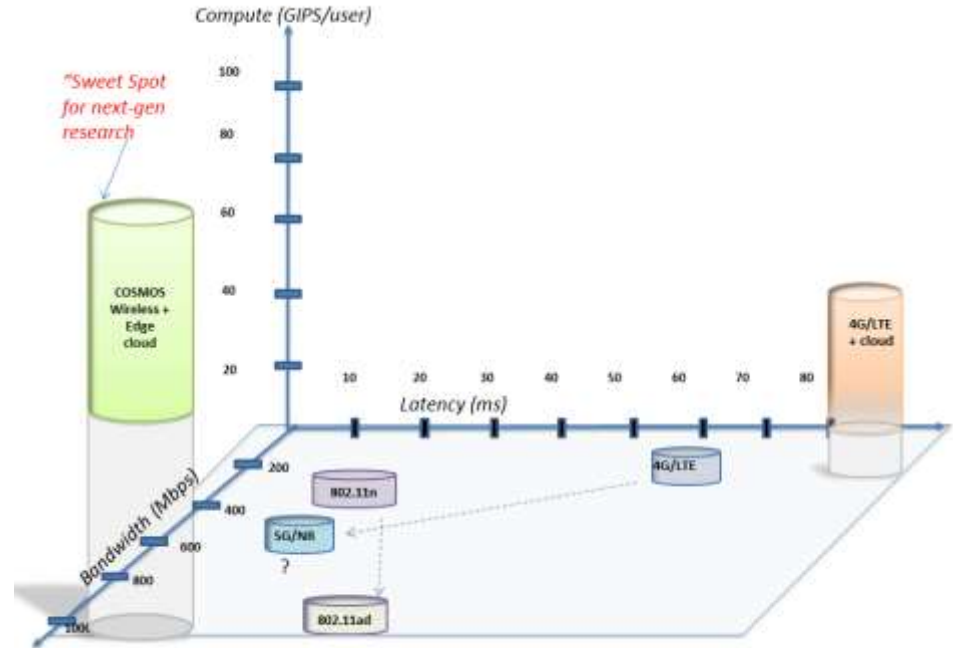
COSMOS: Project Vision (1)

- Wireless speeds are on a faster-than-Moore's law curve.....
- Services now evolving from high-speed data and video towards AR, VR and IoT with real-time "human-in-the-loop"
- Fast changes in technology and services motivate city-scale next-gen wireless testbed for use by both academic and industry researchers → PAWR



COSMOS: Project Vision (2)

- Latency and compute power are the two new dimensions for characterizing wireless access
- Latency for 4G cellular > 50 ms, while targets for 5G are <10 ms
- Edge computing is the other important dimension for enabling real-time services
- COSMOS will enable researchers to investigate ultra-high speed ~Gbps, low latency <5ms, + edge computing ~10-100 GIPS



COSMOS: Project Vision (3)

- Ultra-high BW, low latency and powerful edge computing will enable important new classes of real time applications
- Application domains include AR, VR, connected car, smart city (with high-bandwidth sensing), industrial control, ...

Augmented Reality



Smart City + Connected Car



Industrial Control

COSMOS: Project Vision (4)

- Living lab research platform to bring together research addressing critical technological, social, and civic challenges facing the world's mega-cities
- COSMOS as research & innovation engine of NYC ecosystem of smart city projects, broadband community initiatives and many startups developing new applications

NYC location enables experiments and stress testing at scales and conditions that are years ahead of other cities

Top 25 hot spots by 2025

Cityscope 2025 city rankings

Rank	GDP ¹	Per capita GDP ²	GDP growth ³	Total population	Children ³	Total households	Households with annual income over \$20,000 ⁴
1	New York	Oslo	Shanghai	Tokyo	Kinshasa	Tokyo	Tokyo
2	Tokyo	Doha	Beijing	Mumbai	Karachi	Shanghai	New York
3	Shanghai	Bergen	New York	Shanghai	Dhaka	Beijing	London
4	London	Macau	Tianjin	Beijing	Mumbai	São Paulo	Shanghai
5	Beijing	Trondheim	Chongqing	Delhi	Kolkata	Chongqing	Beijing
6	Los Angeles	Bridgeport	Shenzhen	Kolkata	Lagos	New York	Paris
7	Paris	Hwasong	Guangzhou	Dhaka	Delhi	London	Rhein-Ruhr
8	Chicago	Asan	Nanjing	São Paulo	Mexico City ⁵	Mumbai	Osaka
9	Rhein-Ruhr	San Jose	Hangzhou	Mexico City ⁵	New York	Delhi	Moscow
10	Shenzhen	Yosu	Chengdu	New York	Manila	Mexico City ⁶	Mexico City ⁶

Link NYC

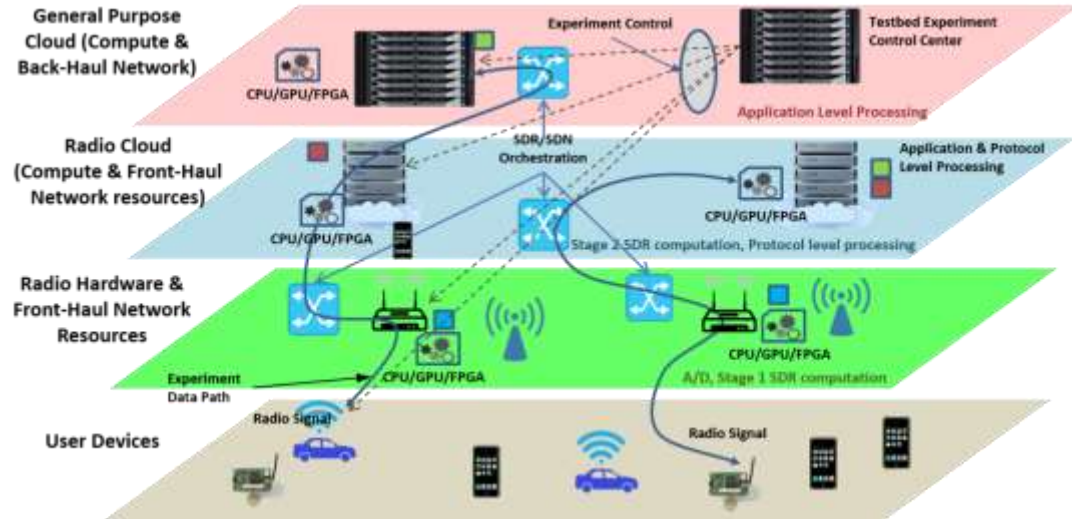


NYC 5G Trials



COSMOS: System Architecture

- COSMOS architecture has been developed to realize ultra-high BW, low latency and tightly coupled edge computing
- Key design challenge: Gbps performance + full programmability at the radio level
- Developed a fully programmable multi-layered (i.e. radio, network and cloud) system architecture for flexible experimentation



Key Technologies going into COSMOS:

Software Defined Radio (SDR)

mmWave Radio

Software Defined Network (SDN)

Optical X-haul Network

Edge Cloud Computing

OMF Control Software



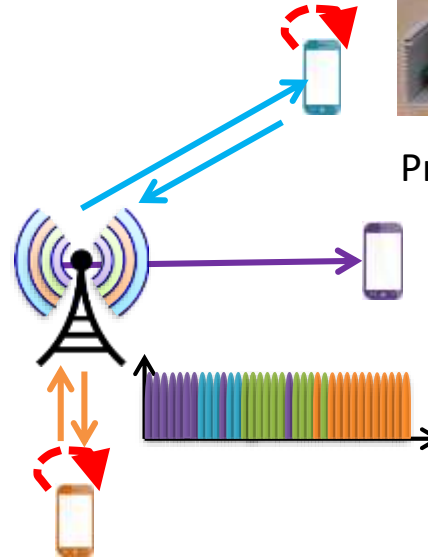
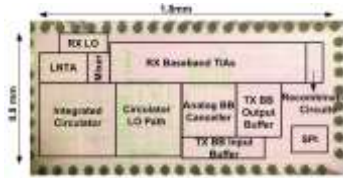
To be covered by next speaker

COSMOS: Experimental Research (1)

Project includes eight internal “**Test Experiments**” (TE) to help drive design requirements

TE on Full-Duplex Wireless:

- Goal: design and evaluate network protocols designed for **IC-based full-duplex nodes**
- Gen-1 node w/ frequency-flat RC canceller, supporting 90dB SIC imparted to 5MHz 0dBm TX signal
- Gen-2 node w/ wideband FDE-based RF canceller, supporting 95dB SIC imparted to 10MHz 5dBm TX signal
- Gen-1 node already deployed in ORBIT to provide the community full-duplex SDRs
- Gen-2 to be deployed in COSMOS
- Real-world experimental evaluation of higher-layer algorithms in heterogeneous networks with both legacy half-duplex nodes and full-duplex nodes



Programmable Gen-1 full-duplex node installed in ORBIT

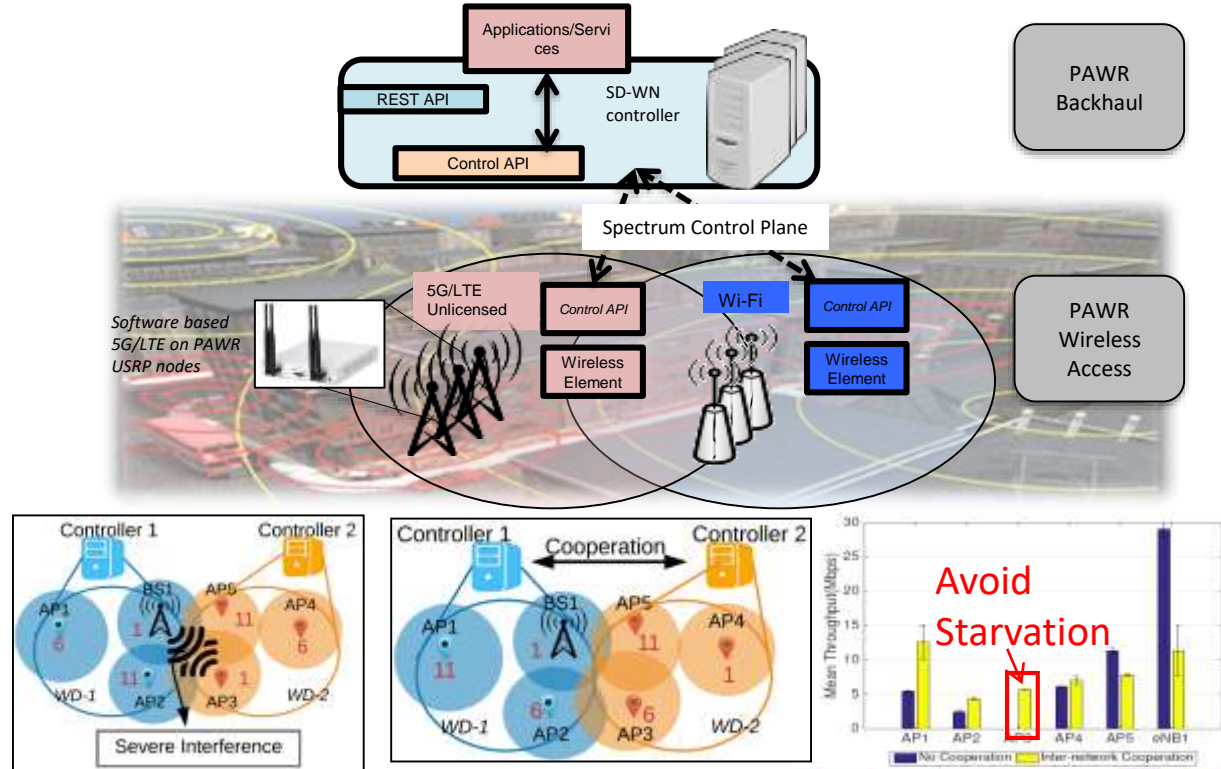


Gen-2 full-duplex link

COSMOS: Experimental Research (2)

TE on Dynamic Spectrum

- Goal is to evaluate cooperative spectrum coordination algorithms in dense city environment
- Multiple technologies (such as WiFi and LTE/5G) in the same unlicensed band
- Experimental evaluation of both distributed and centralized (cloud-based) protocols and algorithms
- Selectable set of radio nodes in COSMOS, with real-world propagation effects



COSMOS: Experimental Research (3)

TE on Vehicular Sensor Sharing and automated driving

- Experiment involves multiple mobile nodes, high BW/low latency wireless access and multiple levels of cloud processing
- Real world traffic and network conditions
- Outcomes include evaluation of system performance and application demo

Automotive Research: Rich Sensor Sharing and Orchestration for Robust Automated Driving

