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NSF Announces New York City as Testbed for New Wave of Mobile Technology

Rutgers, Columbia and NYU to Lead Research Aimed at Pushing Limits of Wireless-Networking

Fourth generation wireless, better known as 4G, turned mobile phones into movie-streaming platforms, but the next wireless revolution promises more than speedy downloads. It could pave the way for surgeons operating remotely on patients, cars that rarely crash, and events that can be vividly experienced from thousands of miles away.

To realize this vision of the future, the National Science Foundation (NSF) and an industry consortium are investing $100 million in the next seven years to build a set of wireless networks for U.S. researchers to test new ways of boosting Internet speeds to support data-intensive applications in robotics, immersive virtual reality and traffic safety. New York and Salt Lake City are the first cities to receive funding under the NSF Platforms for Advanced Wireless Research (PAWR) initiative, with New York set to receive $22.5 million.

Led by researchers at Rutgers, Columbia and NYU, and in partnership with New York City, Silicon Harlem, City College of New York and University of Arizona, the platform in New York, called COSMOS, will be a proving ground for a new generation of wireless technologies and applications. The COSMOS testbed will cover one square mile in West Harlem, with City College to the north, Columbia University's Morningside Heights campus to the south, the Hudson River to the west, and Apollo Theater to the east. This vibrant, densely populated neighborhood is seen as an ideal place to push the bandwidth and latency limits of 4G, and even fifth-generation wireless technology, or 5G, which carriers are starting to roll out in some cities now.

By 2020, the number of Internet-connected devices is expected to grow to 20 billion, creating an urgent need in the U.S. and abroad for infrastructure that can rapidly process all that data. To improve networking speeds, the New York City COSMOS network will tap previously unused radio spectrum bands and integrate optical fibers underground with radio antennas and other equipment on city rooftops and light poles.

The high-bandwidth, low-latency network is expected to allow applications to transmit data faster than one gigabit per second and reduce response times to a few milliseconds, improving performance 10-fold over current wireless networks. To achieve this high level of performance,

data-processing will be handled by on-site "edge cloud" servers rather than in far-off data centers.

The open-access COSMOS platform will allow researchers from anywhere in the country to log in and try out their ideas for improving network performance and creating city-focused applications, from augmented-reality navigation for the blind to "smart" traffic lights.

"COSMOS is an outdoor laboratory that will allow us to test entirely new classes of wireless applications such as smart intersections that can process massive data in real-time," said principal investigator Dipankar Raychaudhuri, an engineering professor at Rutgers University-New Brunswick, and director of its Wireless Information Network Laboratory, or WINLAB.

The technologies underpinning the experiments will include:

- **mm-Wave Radio Bands:** The use of new millimeter-wave bands, from 20 GHz to 200 GHz, will make it possible to extract more capacity from the radio spectrum, but one drawback is that mmWave signals don't travel as far. To overcome this, researchers will use the network to test new radio and antenna designs and techniques for aiming radio waves directly at mobile devices.
- **Software-Defined Radios:** Processing signals with software rather than hardware increases network flexibility and allows researchers to experiment with a wide range of frequency bands. The radios will be used to test new algorithms to support mmWave and flexible use of frequencies across various bands, a feature known as dynamic spectrum access.
- **Edge Cloud:** By shifting data-processing from cloud-based data centers to servers integrated into the wireless access network, researchers can speed up processing time. This is especially critical for applications involving Internet-connected devices that require fast response time.
- **Advanced Optical Networking:** To use edge-cloud infrastructure effectively, a fast front-haul network with high bandwidth and low-delay connectivity is needed to tie together computing clusters and the wireless access network. COSMOS will offer this connectivity with state-of-the-art wavelength division multiplexed optical technology.

New York's tech sector is now the nation's third largest, after Texas and California, with most of those jobs concentrated in New York City, according to a recent New York State Comptroller report. The City has embraced the COSMOS project for its potential to create far-ranging public benefits. These include bringing startups to the neighborhood that can build smart-city applications that make cities safer and more resilient. Applications to come out of COSMOS could reduce the number of crashes that injure and kill drivers and pedestrians, improve accessibility for people with disabilities, and make next-generation 911 systems more secure.

"We are eager for the opportunity to accelerate the development of new products and services based on advanced wireless technology, and shrink their time to market in New York City, benefitting millions of residents and visitors," said Chief Technology Officer Miguel Gamiño, Jr.

The project will also provide hands-on STEM training for students and West Harlem residents who will be among the first to see and touch technologies that are still years away from appearing on the market. Silicon Harlem will involve K-12 students from the community and City College will partner with researchers to involve its engineering students and support the testbed installation.

One key piece of radio equipment to be piloted will be the millimeter-wave wireless antennas and radio front-ends that will be unique to COSMOS. These mmWave radios will operate at 28 GHZ, a frequency recently made available by the U.S. Federal Communications Commission.

The COSMOS research team is led by Raychaudhuri and Ivan Seskar at Rutgers, and Gil Zussman and Sundeep Rangan, electrical engineering professors at Columbia Engineering and New York University's Tandon School of Engineering respectively.

The Rutgers team and WINLAB will build on extensive research experience with wireless testbeds, software-defined radio technology, and mobile Internet architecture. WINLAB's open-access, NSF-funded ORBIT wireless-testbed is currently used by researchers nationally to run controlled experiments at scale. Other COSMOS team members include electrical engineering professors Marco Gruteser and Narayan Mandayam, and computer science professor Thu Nguyen.

The Columbia team will build on ongoing research in mmWave, cross-layering and optical systems for wireless networks, and dynamic spectrum access. The team will leverage Columbia buildings and vehicles for the testbed deployment, which will also serve as a platform for community outreach. In addition to Zussman, the team includes electrical engineering professors Zoran Kostic and Harish Krishnaswamy, and computer science professor Henning Schulzrinne, all members of Columbia's Data Science Institute; and Columbia Chief Technology Officer Alan Crosswell. The team is also partnering with University of Arizona on the advanced optical-networking research, led by optical sciences professor Dan Kilper who is affiliated with Columbia.

The NYU team will build on its extensive experience with mmWave, design and operation of wireless testbeds, and using testbeds for STEM education. In addition to Rangan, the team includes electrical engineering professors Shivendra Panwar and Thanasis Korakis.

Oversight of the NSF PAWR effort is being led by Washington D.C.-based nonprofit, US Ignite, Inc. and Northeastern University.

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Media Contacts

Diane Reed, **Rutgers University-New Brunswick School of Engineering**
(o) 848-445-7359 (cell) 732-421-8738 diane.reed@rutgers.edu

Joanne Hvala, **Columbia Engineering**
(o) 212-854-7622 (cell) 917-312-5017 jh3676@columbia.edu

Kathleen Hamilton, **NYU Tandon School of Engineering**
(o) 646-997-3792 (cell) 347-843-9782 kathleen.hamilton@nyu.edu

Kathleen Clark, **NYC Mayor's Office of the Chief Technology Officer**
(o) 212-788-6479 (cell) 646-927-9592 kaclark@cto.nyc.gov

Clarence Mwamba, **City College of New York**
(o) 212-650-7580 jmwamba@ccny.cuny.edu

Lucio Guerrero, **University of Arizona**
(o) 520-621-2336 luciog@email.arizona.edu

Clayton Banks, **Silicon Harlem**
(cell) 347-687-6474 embertime@gmail.com

Brett Weisband, **U.S. Ignite, Inc.**
(cell) 610-291-0588 brett.weisband@us-ignite.org