



UNIVERSITY of OULU
OULUN YLIOPISTO

DEPARTMENT of COMMUNICATIONS ENGINEERING

WIRELESS COMMUNICATIONS EVOLUTION IN GETA ERA AND BEYOND - FROM 2G TO 5G

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Outline

Where was wireless in 1994/95?

What has happened since then

What are the challenges now?

My perspective and view

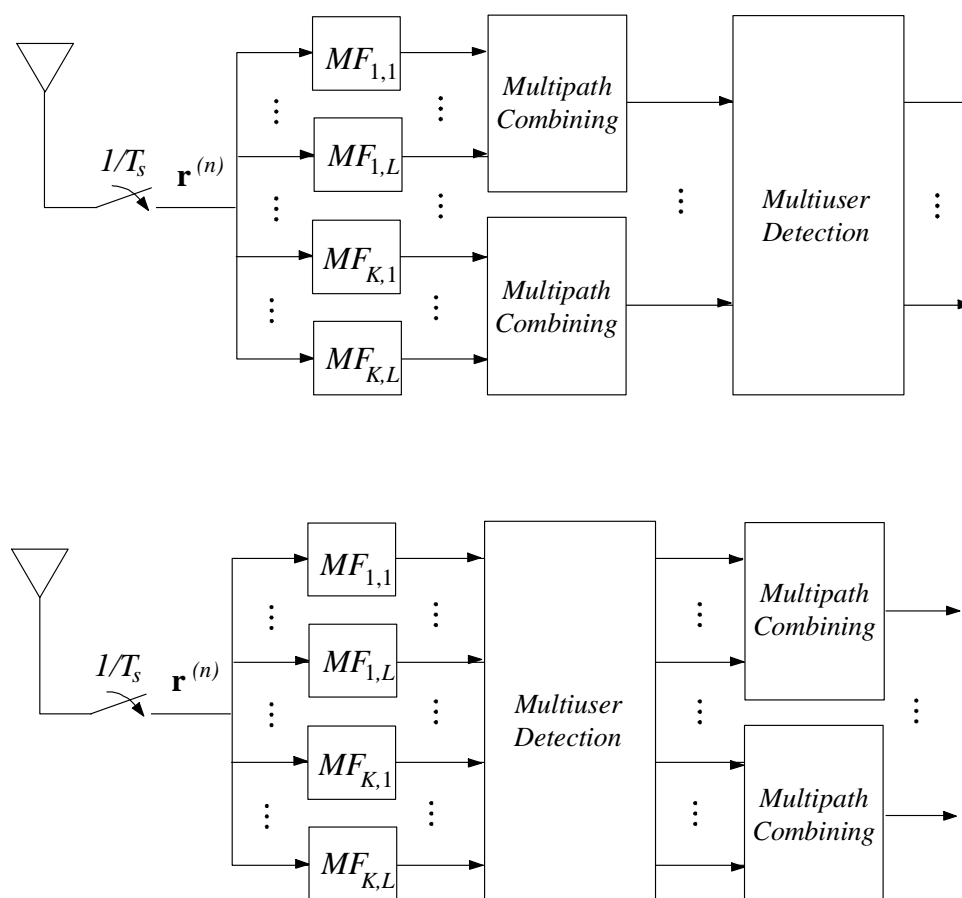
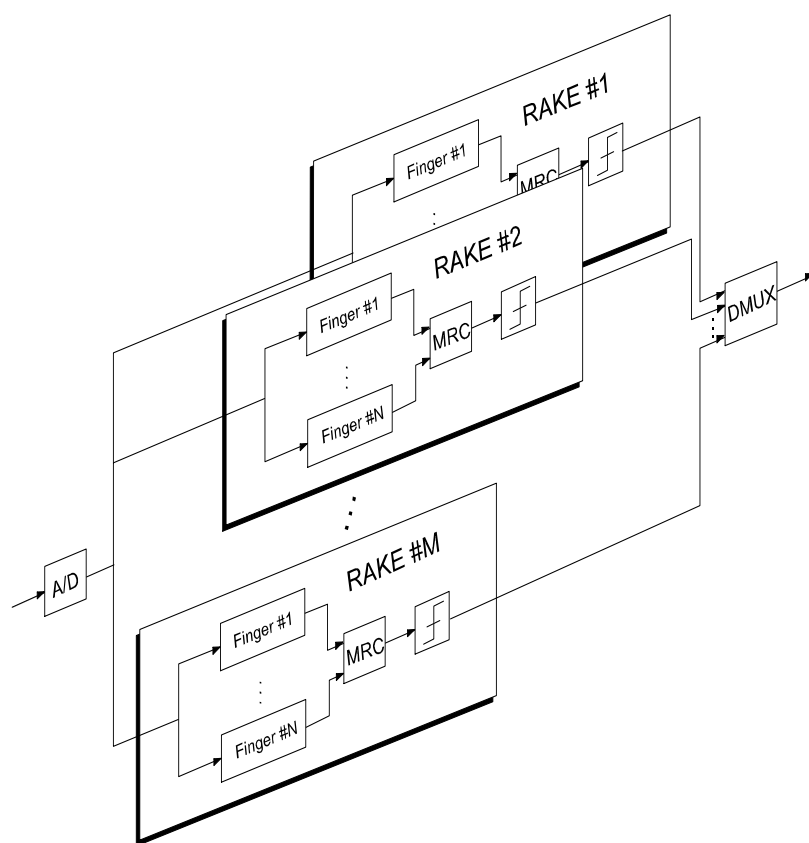
Tekijöiden sukunimet aakkosjärjestyksessä

Where was wireless in 1994/1995?

- 2G GSM taking over 1G analog
- 3G was a research item
- Wireless dominated by voice
 - SMS was probably poorly known for most people
 - Data services almost non-existent
 - 2G+ / GPRS was still to come

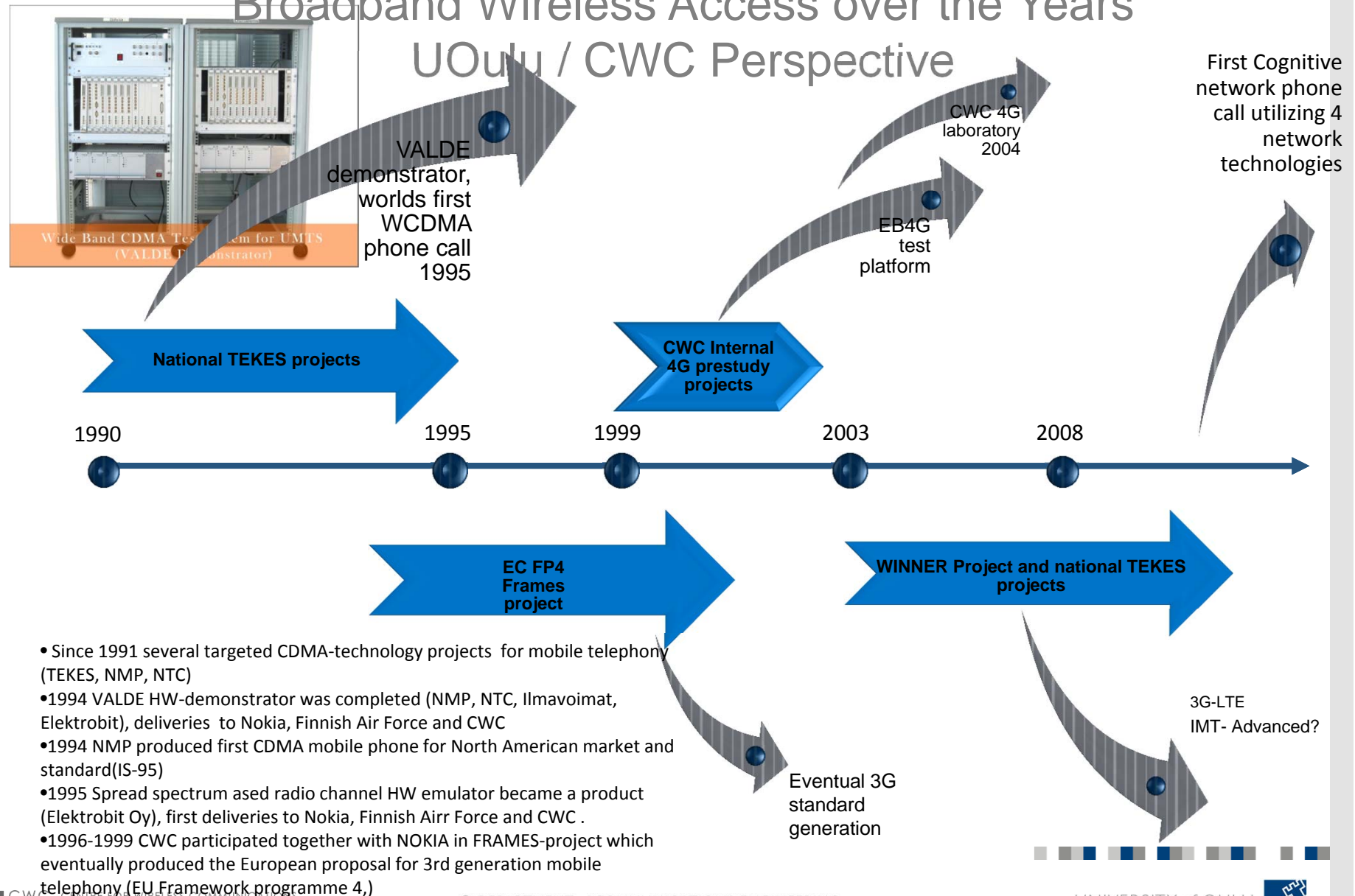


Potential Research Topics in 1994/1995



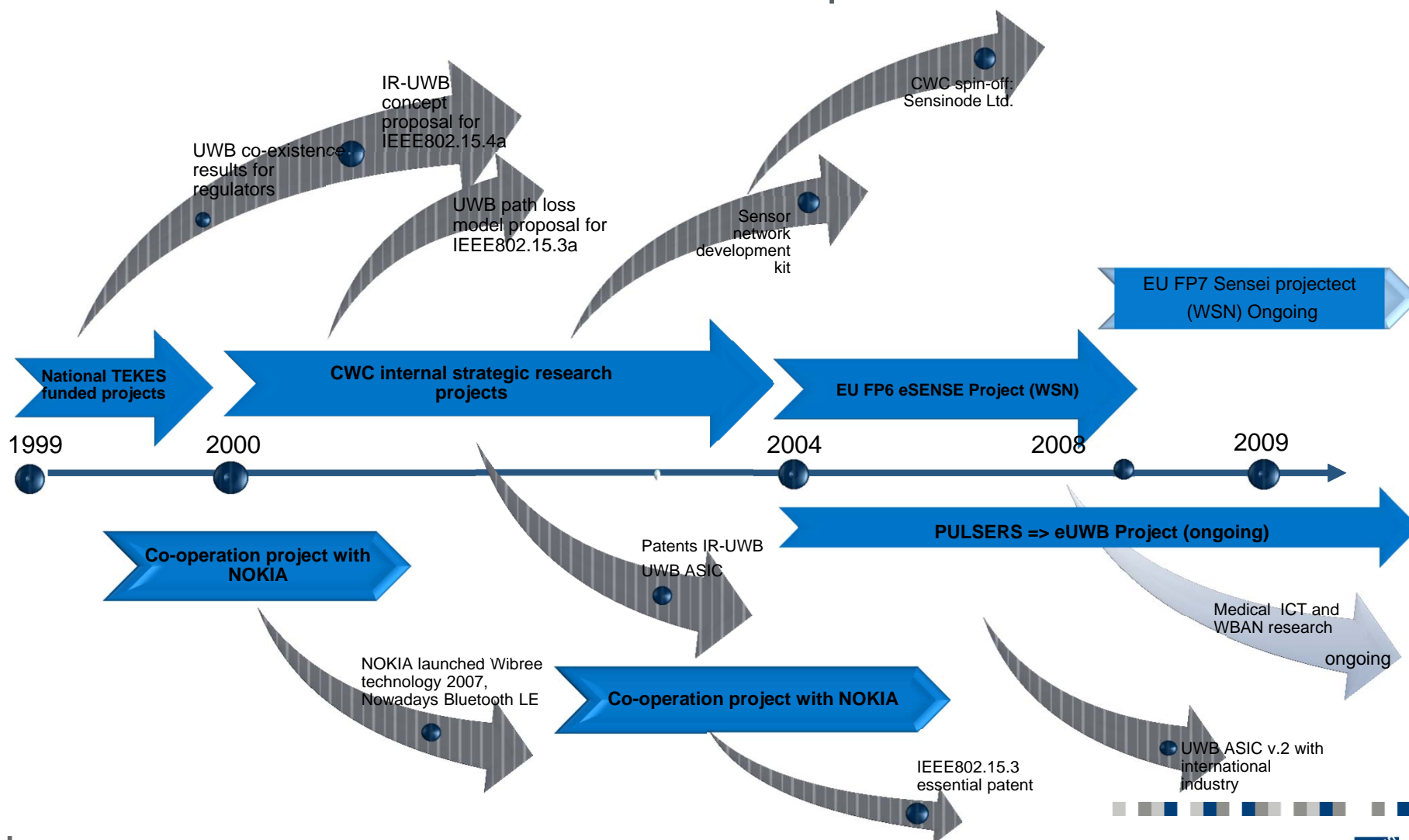
Broadband Wireless Access over the Years

UOulu / CWC Perspective



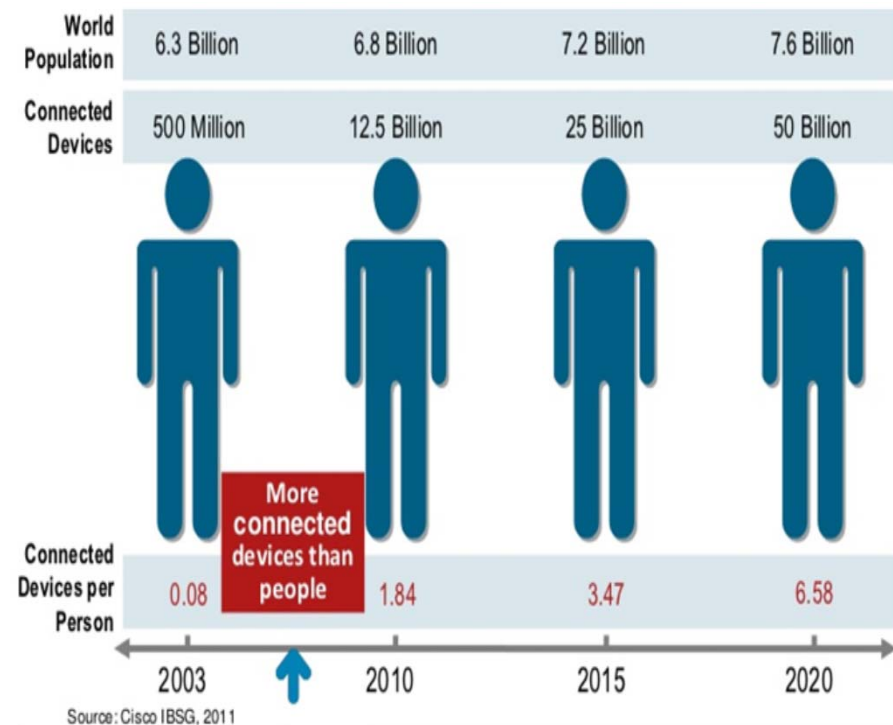
Short Range Communications and Sensor Networks

UOulu / CWC Perspective

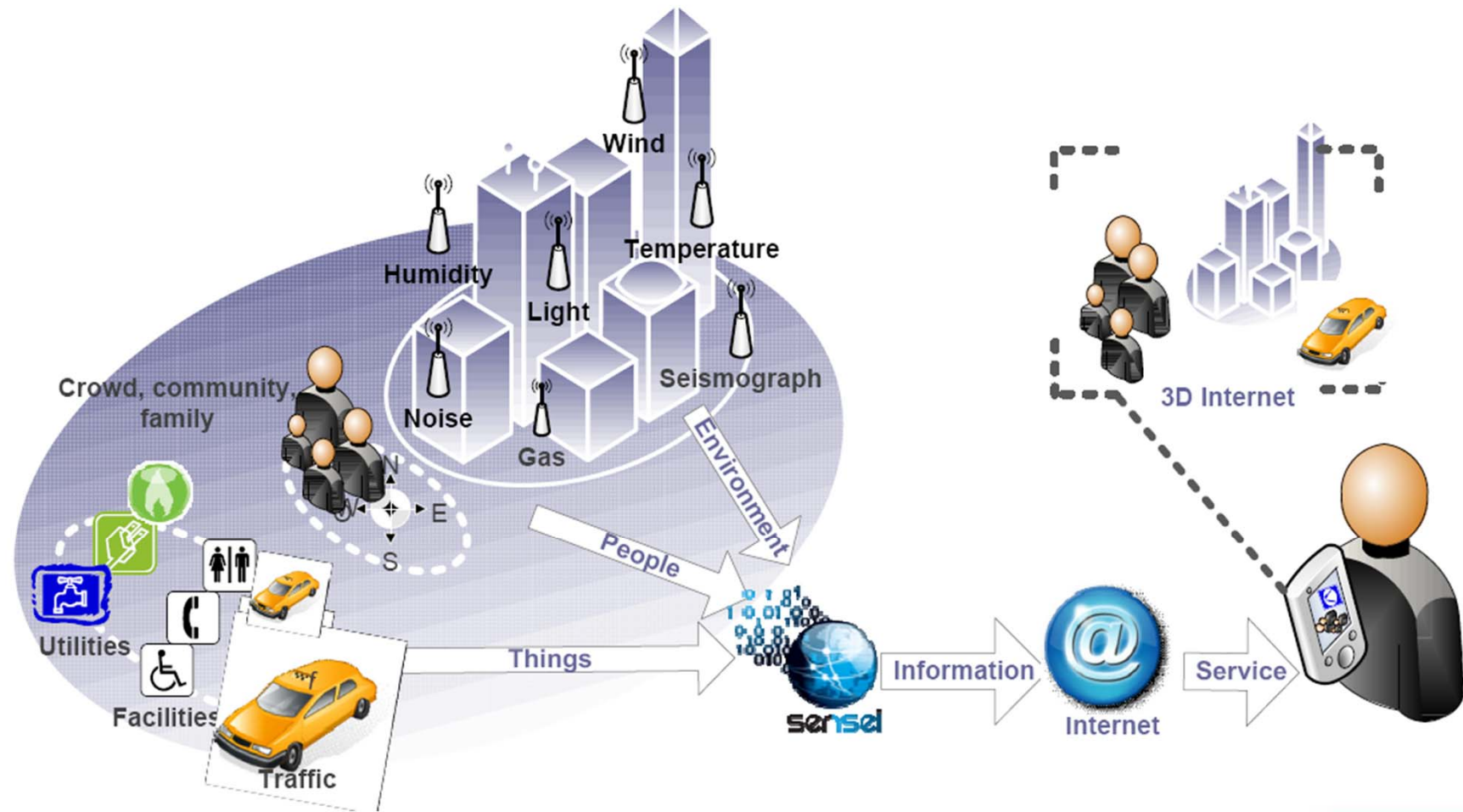


Where is the wireless and ICT now and after ten more years?

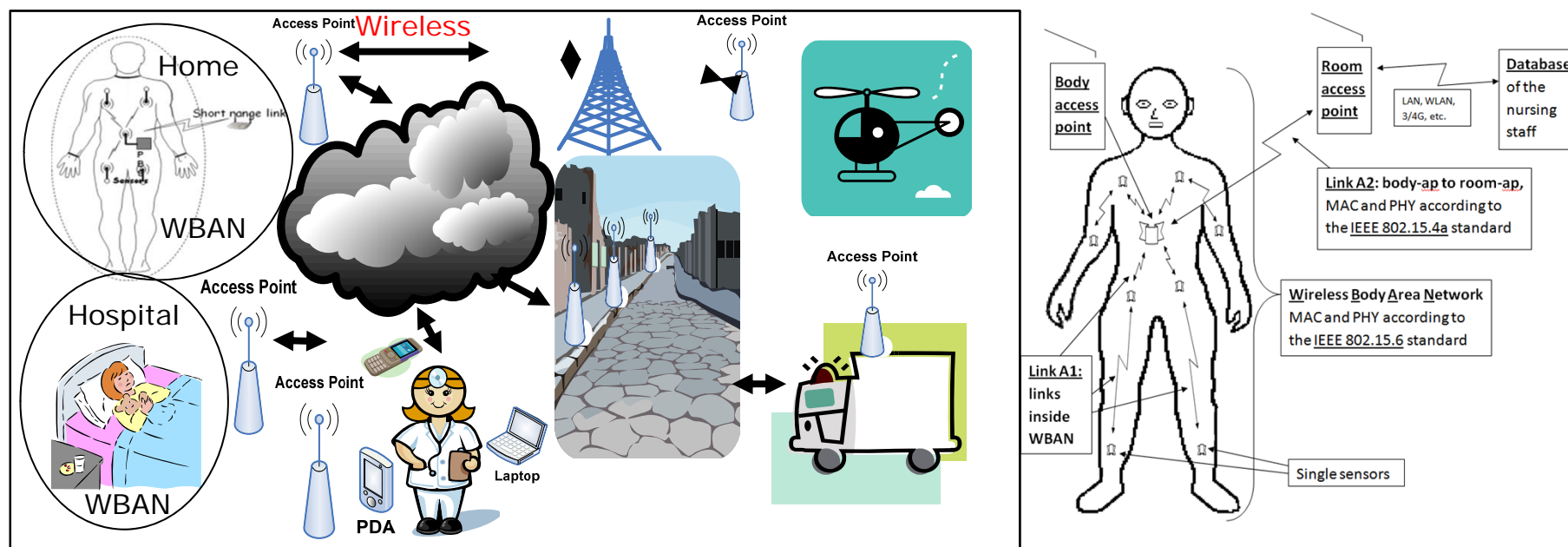
- Wireless more and more pervasive
- Multimedia services
- Smart cities and environments, internet of things (IoT) or connected objects
- Significant energy/power and bandwidth efficiency improvements required
- Also totally new applications, e.g., medical



Smart Cities and Environments

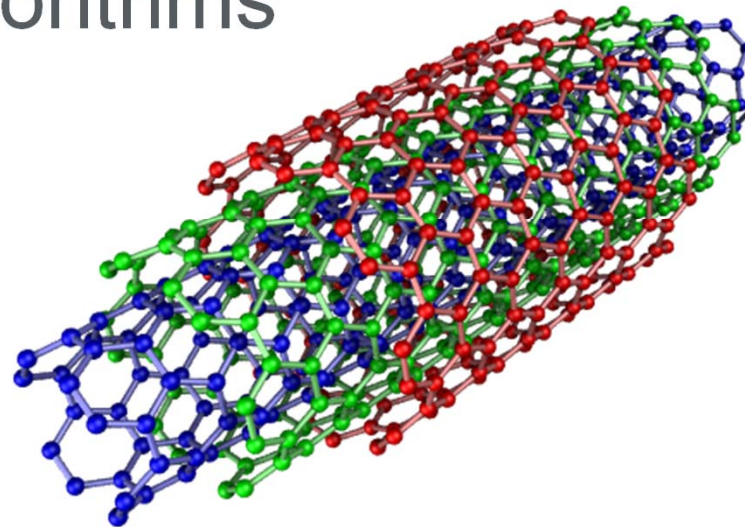
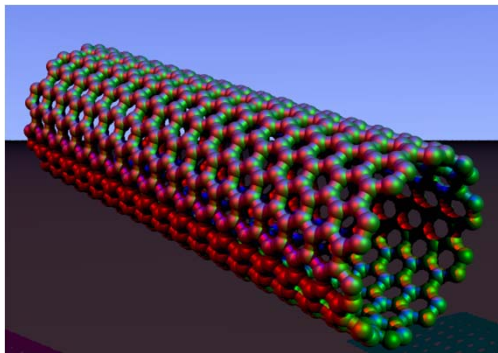


Medical Communications



- Dependable dense WBAN & WSN networks' performance
- Overall access from WBAN to database connection
- On-body and in-body communications & antenna
- Industrial sensor networks & mobile robotics

Nanoscale Communication and Algorithms



- Nanoscale communication devices, protocols and networks, e.g., for in-body communications



Billions of Wireless Devices and Sensors



- 90% of global population has wireless connectivity. ~5B Mobile subscriptions in 2010
- 100,000 phone masts erected annually
- 294 million consumer electronics devices with Wi-Fi shipped in 2007—1 billion by 2012
- Billion of smart dust / sensors:
 - Cisco 2009: Planetary Skin—integrate sensors on land, in sea, in air, and in space to help make it possible to see the “whole picture” when it comes to the effects to and changes in the environment
 - HP 2010—“Central Nervous System for the Earth” CeNSE. 10-year mission to embed up to a trillion push-pin-sized nanoscale sensors and actuators around the globe

Source: Cisco IBSG, UN: International Telecommunications Union, Real-Aliens.Com 2006-2011



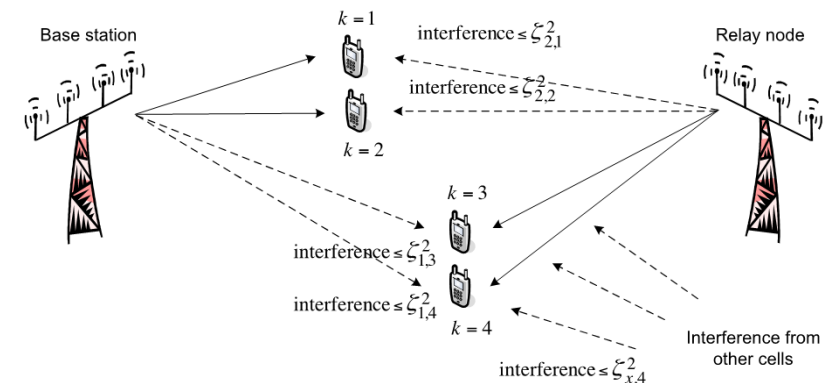
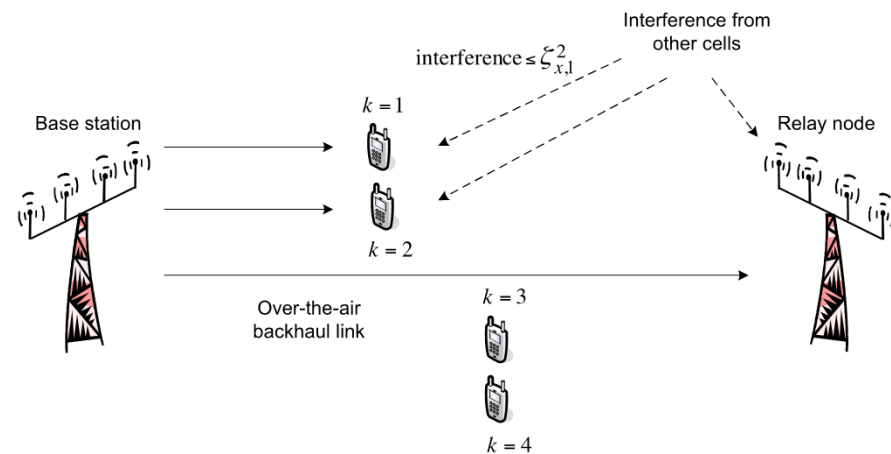
What is needed from 5G then?

- More spectrum
- Better air interface and network technologies
- New approaches for **energy/power** consumptions
- Innovative approaches for data collections/transmissions
- Heterogeneous and dense networks, small cells

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Possible Current Research Topics



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My Five Cents for a Doctoral Student

Fundamentals (math, physics) get never outdated

Software and programs important

Think across the layers and out of the box

What are the requirements of the application?

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THANK YOU FOR YOUR ATTENTION! ANY QUESTIONS?

