



Simulations and QoS in Modern Mobile Networks

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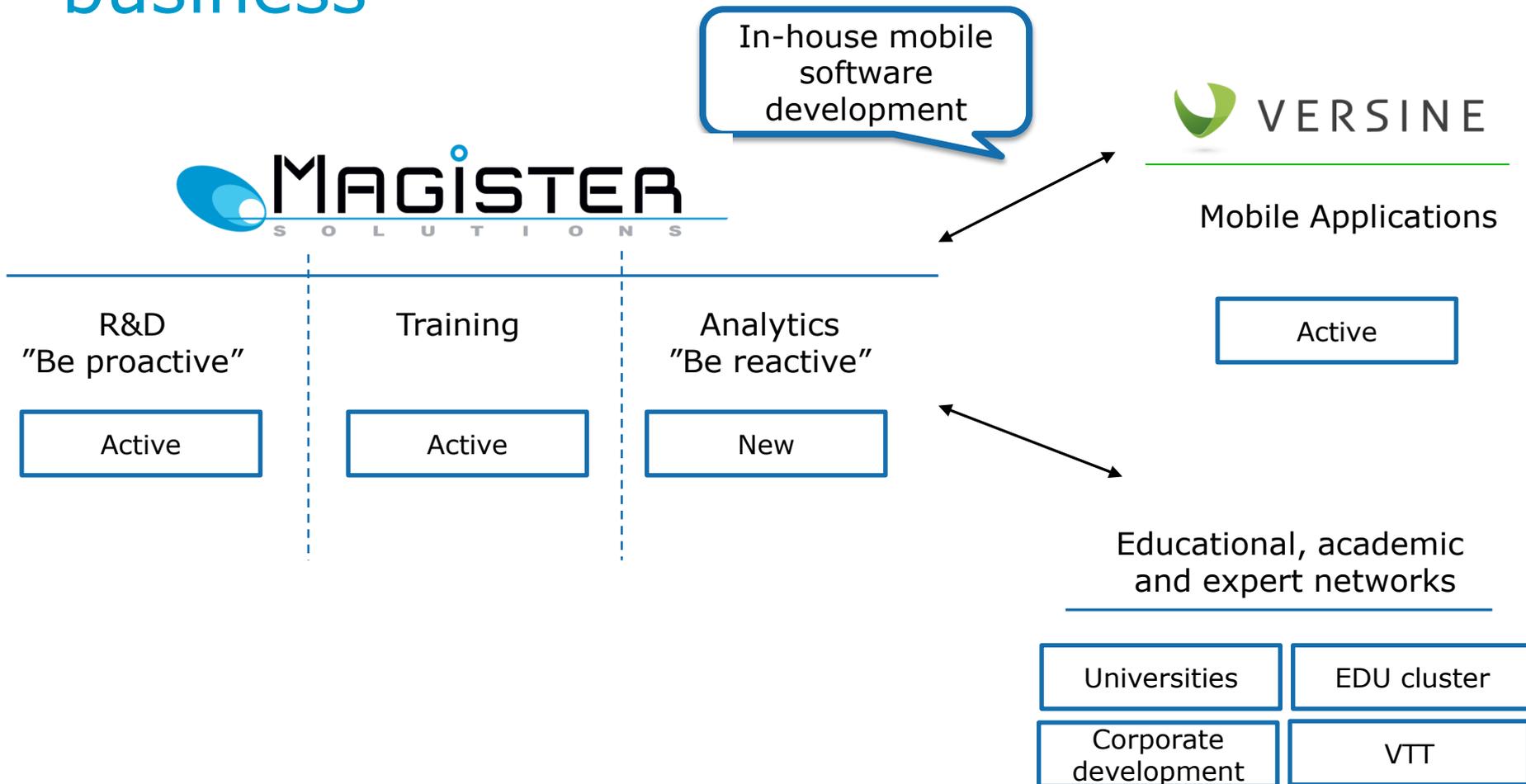
“Essentially, all models are wrong,
but some are useful”

[George E. P. Box and Norman R. Draper. *Empirical
Model-Building and Response Surfaces*. Wiley, 1987]

How may networks be studied?

- **Measurements from real devices / networks**
 - Measurements from real devices
 - Protocol analyzers, i.e. “sniffers”
 - Operator conducted drive tests with specialized equipment
 - Networks / devices may not exist for state-of-the art wireless technologies
- **Test networks**
 - Access to all equipment / software
 - Open-source software
 - Test networks may not be large enough
- **Computer simulations**
 - Faster to achieve results
 - Easier to analyze with different assumptions
 - How reliable are the results?
- **Mathematical analysis**
 - Pen’n’paper, Matlab

Magister Solutions – From science into business



When to use simulations?

- When the **analytical model/solution is not possible or feasible**
- Many times, simulation results are used to **verify analytical solutions** in order to make sure that the system is modeled correctly using analytical approaches.
- **Dynamic systems**, which involve randomness and change of state with time
- **Complex dynamic systems**, which are so complex that when analyzed theoretically will require too many simplifications. In such cases, it is not possible to study the system and analyze it analytically.

Link and system level simulators

- (Mobile) network simulators can be roughly categorized in *link level* and *system level* simulators
 - Link level simulators model in high detail the radio interface between a MT and BS. Link level simulators operate on chip or symbol level
 - System level simulators model a full network usually including multiple BSs and number of mobile stations. Slot-level modeling is sufficient for system simulation (1 slot = 2560 chips = 0.66667 ms)
- Link level simulator output works as input for system level simulators using mapping tables or curves

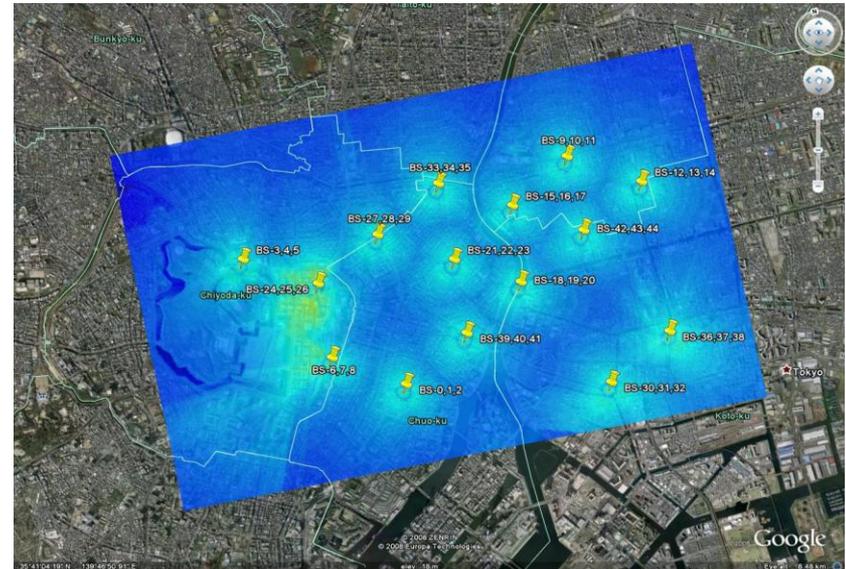
References – Case Tokyo

- Goal:
 - Performance benchmarking between 3G HSDPA and next generation LTE system
- Challenges:
 - It is hard to collect needed statistics from commercial networks
 - It is not affordable to build large enough test networks
 - In relation to LTE, there was only limited commercial products available



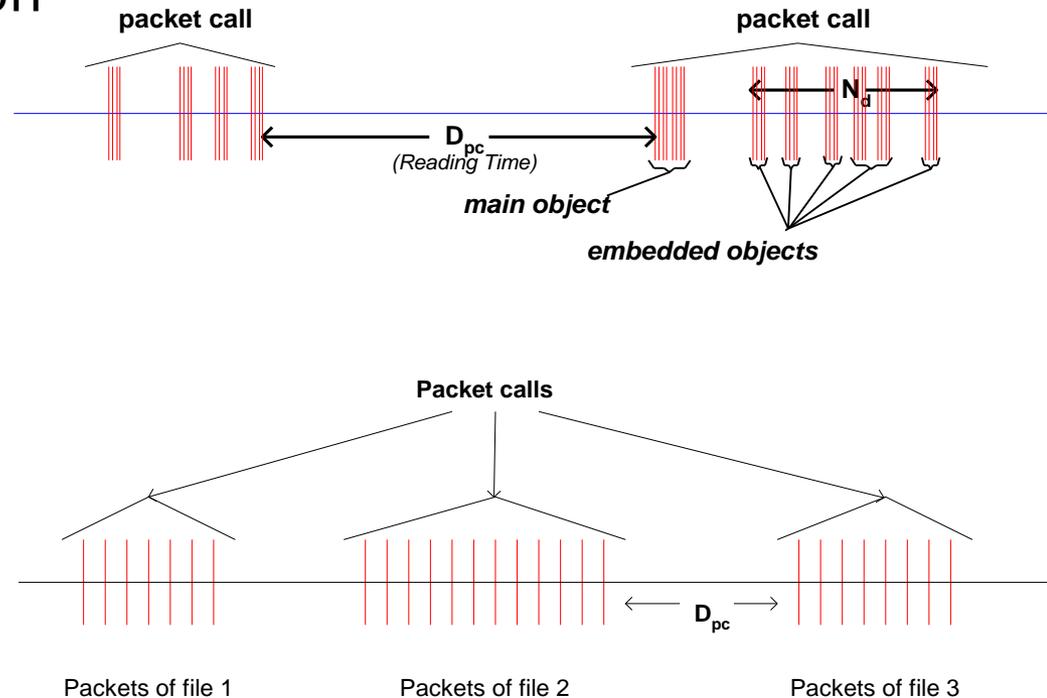
References – Case Tokyo

- Simulation based approach was selected
 - Like many vendors, operators as well as the scientific communities do for studying the wireless cellular network performance
- Digital network planning data over Tokyo map was used in the simulator
 - Realistic conditions through non-regular network layout and propagation



Traffic models

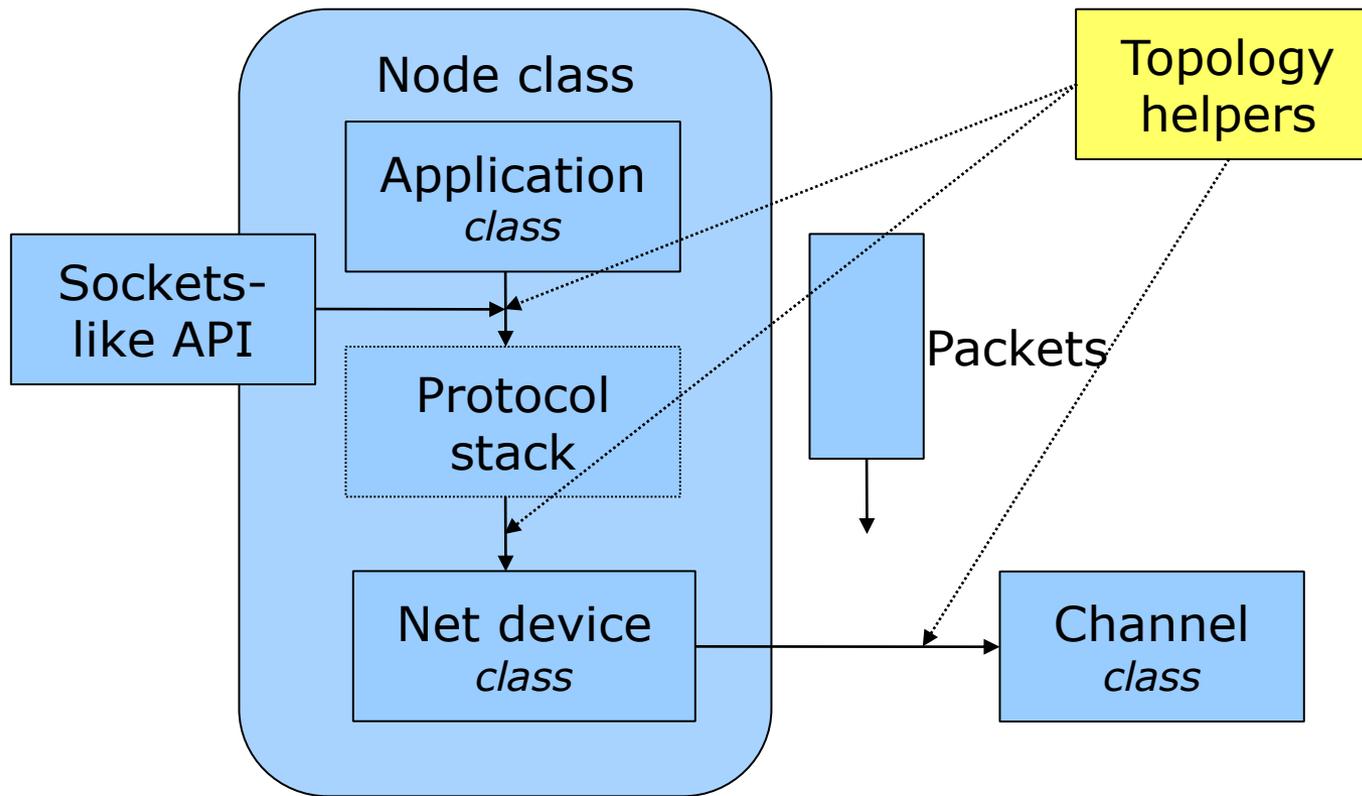
- Defined by standardization organizations
 - Infinite buffer
 - FTP
 - Constant Bit Rate (CBR)
 - HTTP models (bursty)
 - AMR codecs for VoIP



Available simulators

- Most suitable:
 - **Network Simulator-2 (NS-2)** <http://isi.edu/nsnam/ns/>
 - **Network Simulator-3 (NS-3)** <http://www.nsnam.org/>
 - **OMNeT ++** <http://www.omnetpp.org/>
 - openWNS <https://launchpad.net/openwns>
- Other open
 - JiST <http://jist.ece.cornell.edu/>
 - GoMoSim <http://pcl.cs.ucla.edu/projects/glomosim/>
- Proprietary
 - OPNeT <http://www.opnet.com/>
 - QualNet <http://www.scalable-networks.com/products/qualnet/>
 - NetSim <http://tetcos.com/software.html>

NS3: Main objects, attention to realism



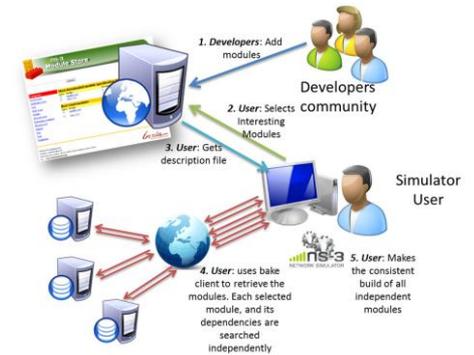
- Model nodes like real computer
- Support key interfaces such as sockets API

SimTools 2012: Program and people

- Friday 23.03.2012: NS3 Workshop
 - Latest ns3 achievements
- Saturday 24.03.2012: NS3 Developers meeting
 - New features, direction of further development
- **Main participants:**
 - *Tom Henderson*, Boeing – founder of ns3
 - *Nicola Baldo*, IICT – LENA module main developer
 - *Mathieu Lacage*, freelancer – one of the main ns3 developers
 - *Kirill Andreev, Pavel Boyko*, Telum - .11s module developers
 - *James Sterbenz*, prof. at The University of Kansas – IP and routing protocols
 - *Tommaso Pecorella*, Università di Firenze – 6LoWPAN

On-going ns-3 development

- LENA/LTE
 - The LENA LTE+EPC model presented in the workshop
 - Coming to main version, possibly divided into two releases
 - Now in code review
 - LENA on-going tasks
 - MIMO
 - RRC: connection setup / release
 - HARQ
 - X2
- Bake – integration tool for ns-3
- The Common Open Research Emulator (CORE)
- Simulation Automation Framework for Experiments (SAFE)

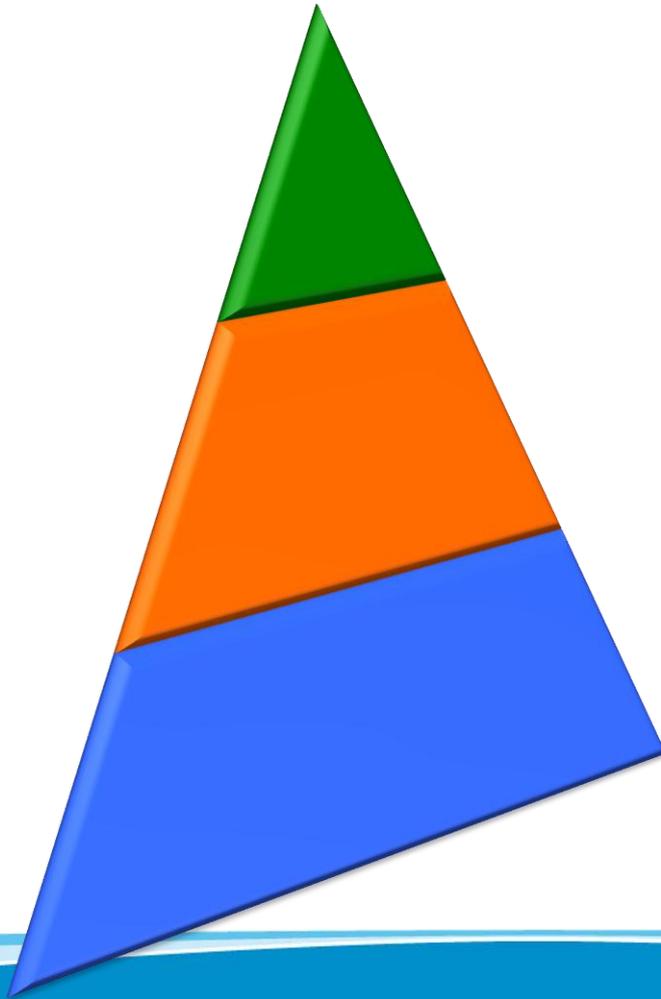


R&D Activities

- **CELTIC+** Initiative: Cooperation for a European sustained Leadership in Telecommunications
 - **CIER** – Converged Infrastructure for Emerging Regions
 - **COMMUNE** – COgnitive network ManageMent under UNcErtainty
- **MESHE** – Management Solutions for Heterogeneous Networks



Quality of Service, vendor's perspective



Revenue optimization

- QoS Differentiation

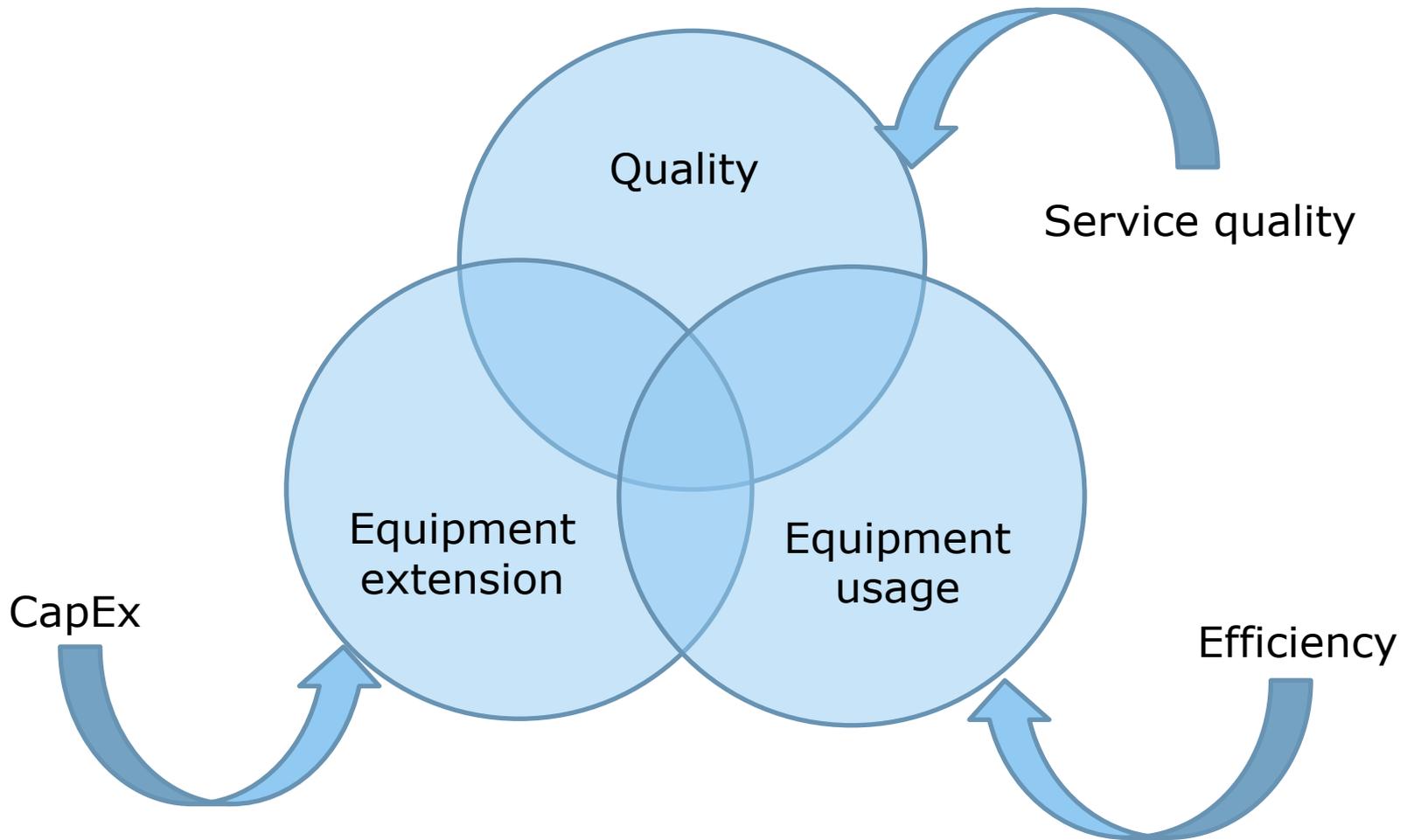
Service optimization

- Mobile broadband and streaming optimization
- QoE analysis and improvement

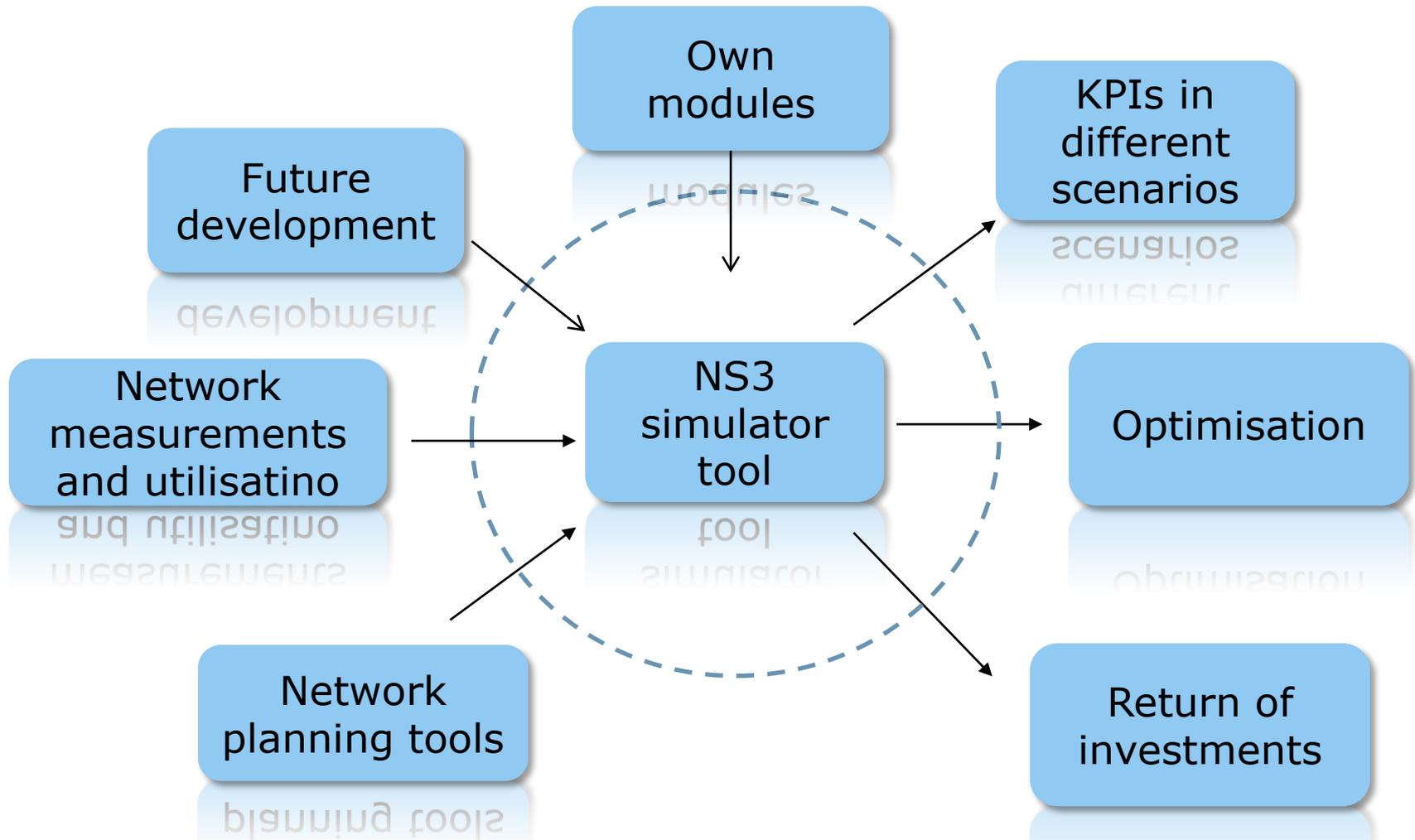
Network optimization

- Multivendor performance optimization
- Capacity optimization

Quality of Service



Simulation of real networks



NS3 working group inside FRUCT?

- NS3 is open source project
- Google summer of code 2012
 - Neighbor Discovery Optimization for Low Power and Lossy Networks (6LoWPAN-nd)
 - Vehicular Ad-hoc Networks
 - Deep Space networking
 - Random Mobility in presence of Buildings
- Important and supervised work for students
- Development of Russian community



Thank you for attention!

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