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MAGISTER SOLUTIONS

SNS3

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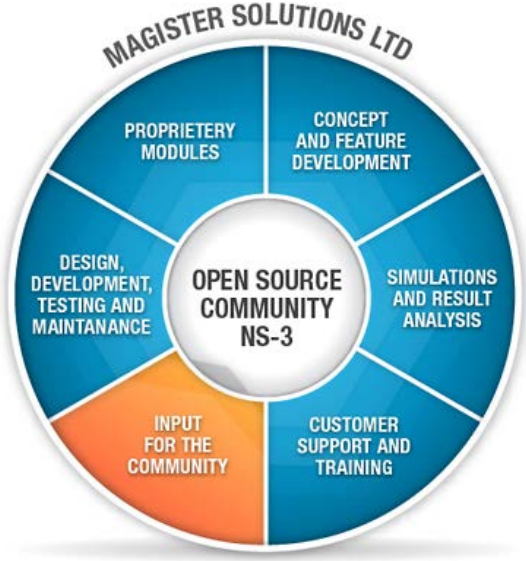
This work has been partly funded by European Space Agency in the scope of ARTES 5.1 AO6947 “Development of an open-source, modular and flexible satellite network simulator” project (contract no: 4000106081/12/NL/NR) and ARTES 5.1 AO7476 “Network Security on Multi-Spot Beam Broadband Networks for Multicast Based Interactive Systems” project (contract no: 4000109719/13/NL/EM



Introduction

- ESA ARTES 5.1 project "Development of an open-source, modular and flexible satellite network simulator”
- An open-source software-based network simulator, which models:
  - Geostationary interactive multi-spot beam satellite networks with transparent payload
  - DVB-RCS2 and DVB-S2 communication protocol stacks
  - Project finalized in October 2014

- A packet-level Satellite Network Simulator 3 (SNS3) model is developed on top of Network Simulator 3 (NS-3) platform
  - NS-3 is an open source discrete-event simulator platform aimed to enable modern networking research
  - NS-3 is highly modular, widely used and fast
  - http://www.nsnam.org/

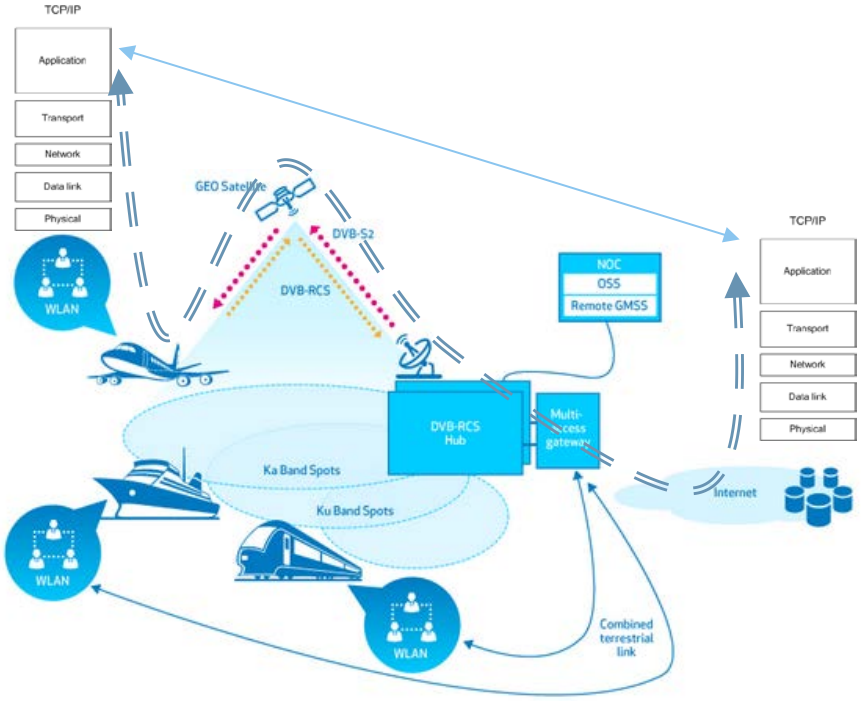
Design assumptions and principles

- Modular and flexible packet and system level simulator
- Extensibility, configurability
- Open-source (ns-3)
- Geostationary satellite with transparent bent-pipe payload
- DVB-S2 and DVB-RCS2 specifications adopted to the simulator
- Radio resource management algorithms

- **Common platform for ESA studies to reduce the consecutive effort for simulation software development activities**

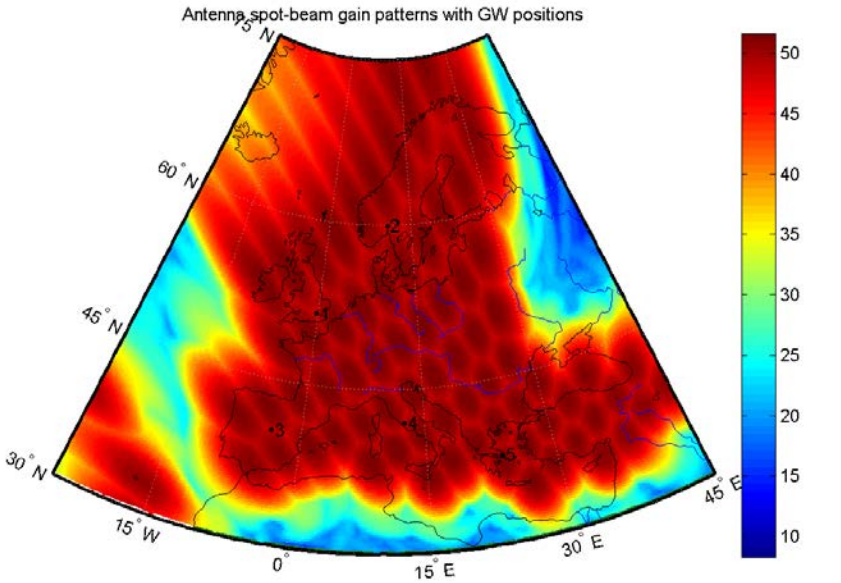
Objective

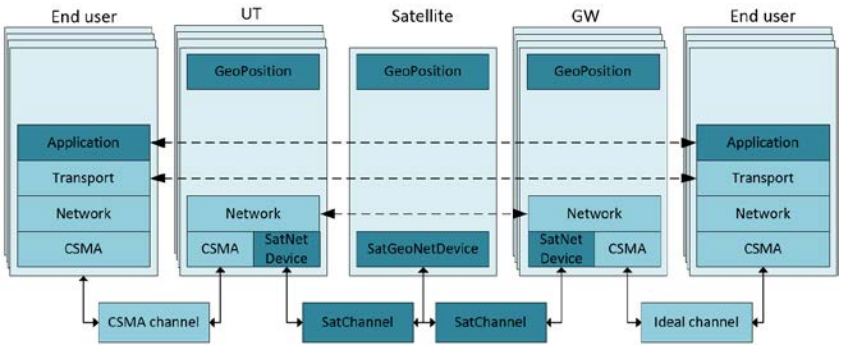
- SatCom R&D tool/simulator
  - Communication protocol simulator
  - Packet level simulator (resolution)
  - Dynamic simulator (mobility, time)
  - Network simulator (not only one link)
  - E2E simulator
  - By default – non-real time
- Use case: geostationary multi-spot beam satellite networks
  - For satellite system standardization
  - For product development
  - For new system design and parameter optimization
  - Performance evaluation and optimization of existing systems



Satellite system

- Interactive multi-spot beam satellite network with transparent 'bent-pipe' payload on geostationary orbit
- Based on DVB-RCS2 and DVB-S2 specifications in RTN and FWD links
- Ka-band frequencies in user and feeder links
- Coverage area of Europe
- Configurable amount of UTs, 72 spot beams, 5 gateways, Network Control Centre (NCC)
- Terrestrial access e.g. Ethernet, WiFi, LTE, …





Higher level features

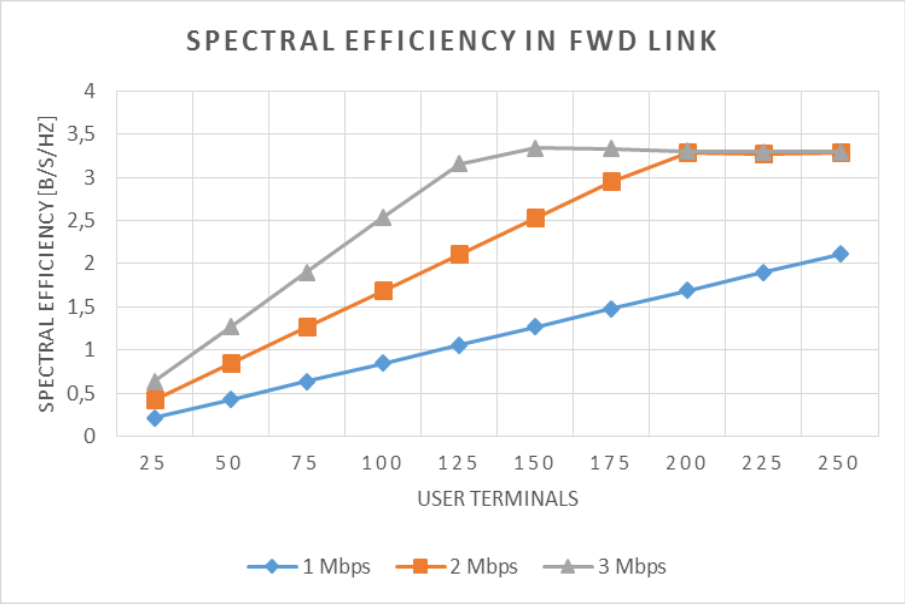
- End-to-end simulations from end user attached to satellite UT to service and content provider at the core network
- Analysis of all communication protocol layers of TCP/IP protocol stack: e.g. data link, network, transport, application
- Possibility for heterogeneous simulations with e.g. Ethernet, WiFi, LTE, Wimax, satellite, …
- Possibility of attachment to real protocols and applications by means of real-time emulation support
- NEF player visualization

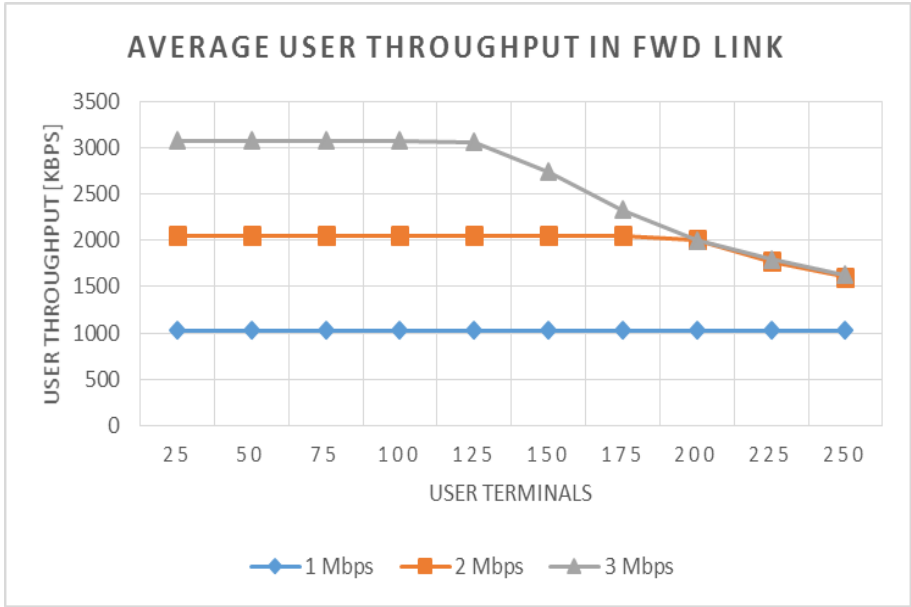
Satellite link features

Layer	FWD link	RTN link
Physical (PHY) / channel	Propagation delay, Land Mobile Satellite channel, Free-Space Loss (FSL), antenna gain patterns, Rx power calculation, weather traces, noise, interference, link budget parameterization, error modeling	
Medium Access Control (MAC)	FWD link scheduler, ACM, Base Band (BB) frame container	Random access (slotted ALOHA, Contention Resolution Diversity Slotted ALOHA (CRDSA)), UT scheduler, Terminal Burst Time Plan (TBTP) receiver
Logical Link Control (LLC)	GSE encapsulator, RLE decapsulator, Automatic Repeat request (ARQ), packet queue(s)	DAMA request manager, RLE encapsulator, GSE decapsulator, ARQ, packet queue(s)
Packet classifier	Differentiated Services Code Point (DSCP) to flow identifier mapping	
Satellite	Transparent star, non-flexible payload	
Network Control Centre (NCC)	-	RTN link burst scheduler, ACM

Layer	
Network layer	IPv4, IPv6, Internet Control Message Protocol (ICMP), Mobile IP(*), Open Shortest Path First (OSPF)(*), Multicasting
Transport layer	User Datagram Protocol (UDP), Transport Control Protocol (TCP), Stream Control Transmission Protocol (SCTP)(*)
Traffic models	On-off, HyperText Transfer Protocol (HTTP), Near-Real Time Video (NRTV), Constant Bit Rate (CBR)
Statistics	Throughput, delay, signaling load, queue size, SINR, error probability, frame load, waveform usage, requested resources, granted resources, …
Terrestrial networks	CSMA, Wi-Fi, Point-to-Point, LTE, Wimax

FWD link performance

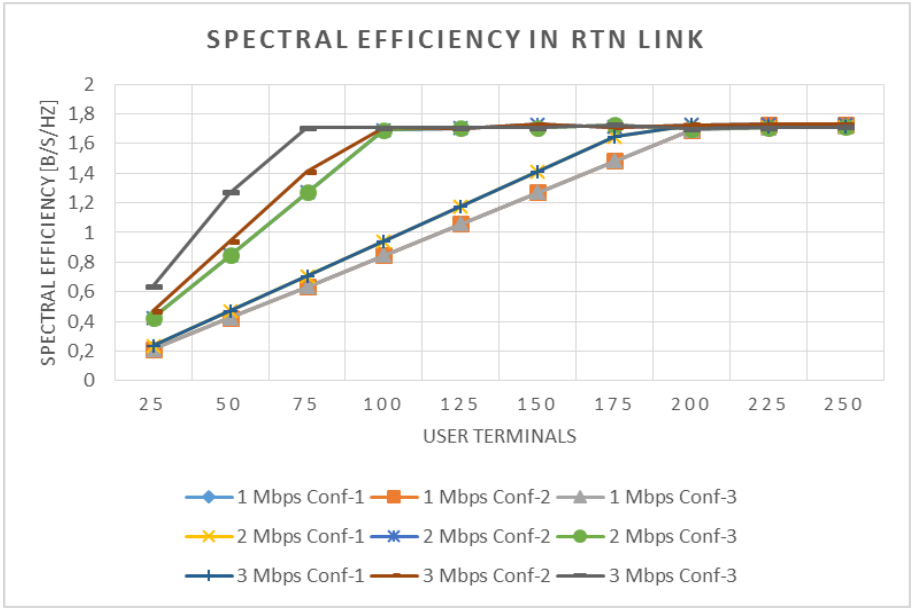


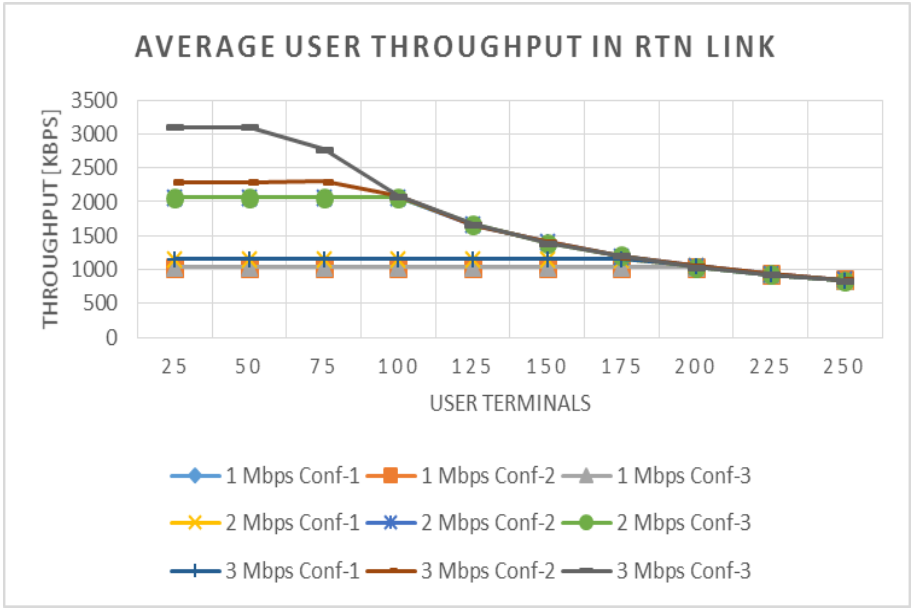


- Spectral efficiency saturates to 3.3 b/s/Hz -> **32APSK and LoS conditions**
  - >250 users per beam at 1 Mbps
  - ~200 users per beam at 2 Mbps
  - ~125 users per beam at 3 Mbps

RTN link performance

Conf-1 – 625 kHz
Conf-2 – 1.25 MHz
Conf-3 – 2.5 MHz





- Spectral efficiency saturates to 1.7 b/s/Hz -> **LoS conditions**
  - Highest usable modulation is 16QAM (compared to 32APSK in FWD link)
  - Carrier spacing consumes bandwidth of MF-TDMA system
  - UT is capable of being scheduled to only one carrier at a time
  - DAMA procedures
- With 3 Mbps of offered load, only the carrier bandwidth of 2.5 MHz can offer 100% satisfaction

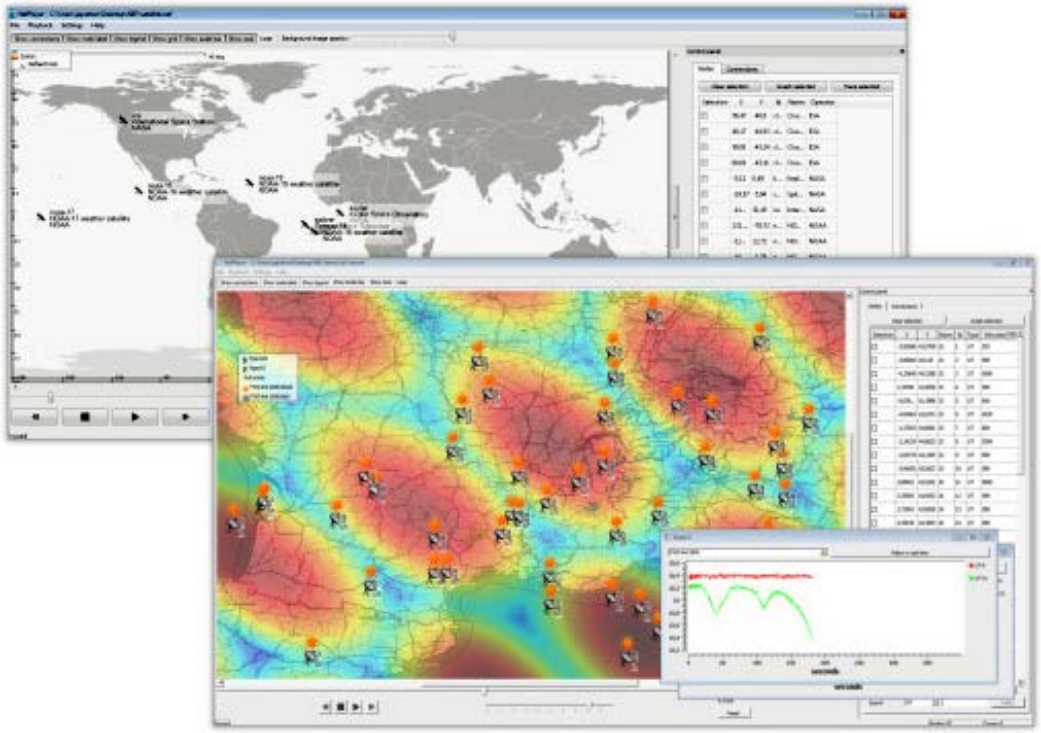
Simulator use cases

- R&D tool for satellite network vendors, integrators, operators, organizations, …
  - Algorithm and protocol design, development and optimization, e.g. Radio Resource Management (RRM)
  - Building Proof-of-Concept for new features
  - Full satellite system performance analysis and end user quality of service verification
  - Hybrid scenarios: e.g. integration between satellite and terrestrial networks



Network Event File (NEF)

- Simulator independent visualization/demonstration tool
  - Node state
  - Events
  - Node mobility
  - Configured set of KPIs

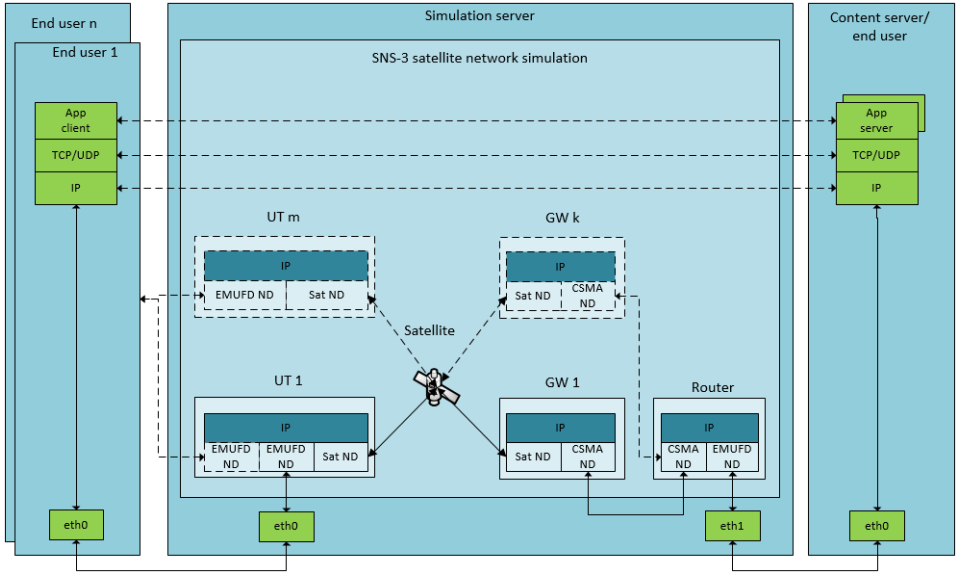


SNS3 in real-time emulation mode

- The connection of the simulation and real world is done by installing an additional file descriptor (FD) *net device* in the simulated ns-3 node
- *FdNetDevice* is able to interact with an external device by using an FD defined by the developer
  - ***TAP FdNetDevice***, which creates a virtual network tap interface on the host machine upon the start of the ns-3 simulation. This approach is suitable for scenarios with virtual end nodes running on the same host as ns-3.
  - ***EMU FdNetDevice***, which directly connects to a physical interface of the host machine. This approach may be utilized in scenarios where no virtualization is used.

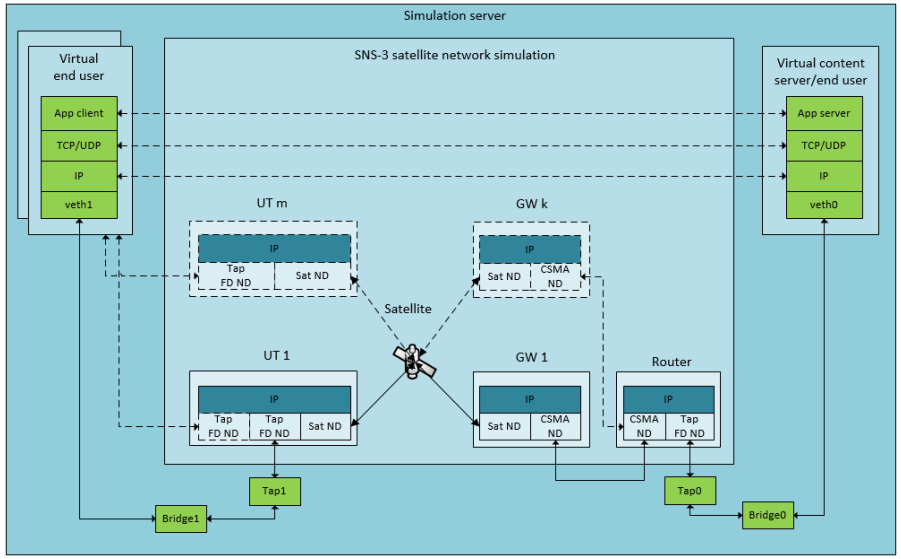
Example integration to a test bed

EmuFdNetDevice



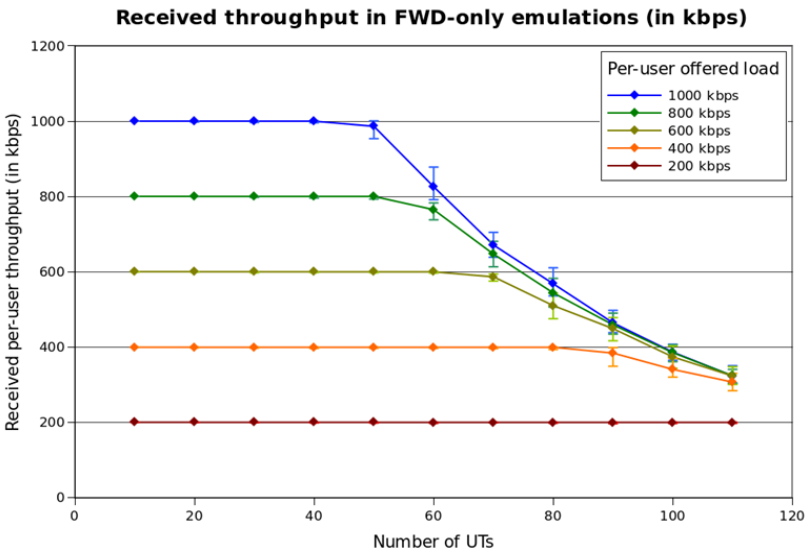
”Attaching real devices”
ESA ISD 2014

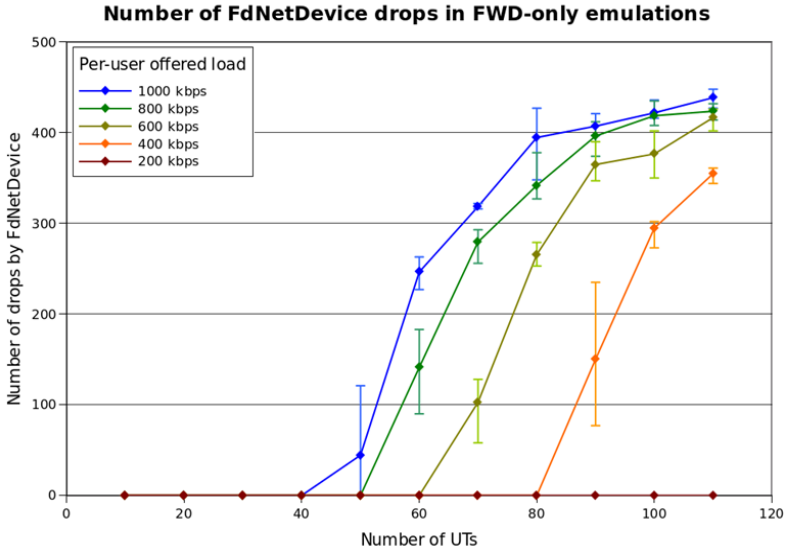
TapFdNetDevice



”Attaching virtualized devices”
KaConf 2014

Emulated FWD link performance

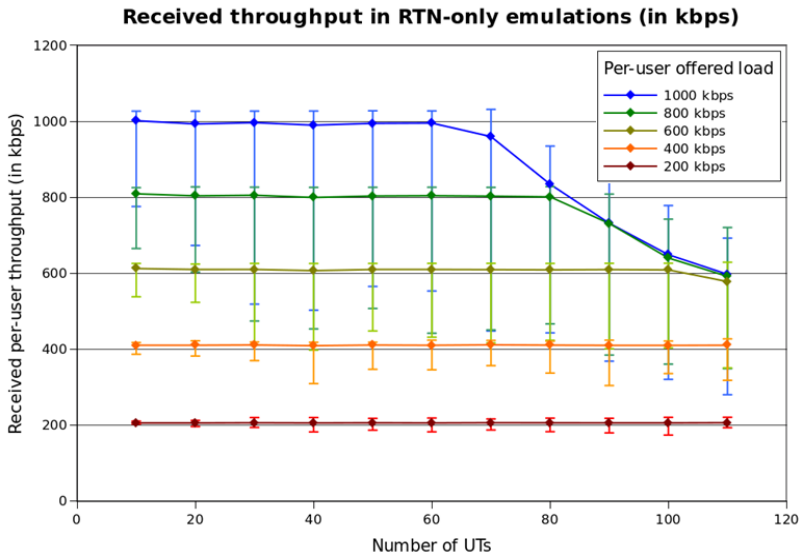


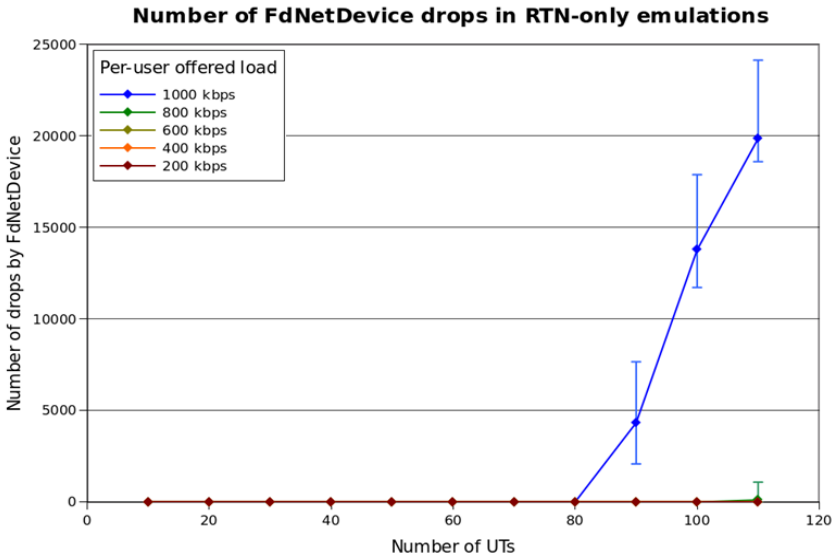


- Much lower capacity if compared to previous simulation results
  - >110 users per beam with 200 kbps
  - ~90 users per beam with 400 kbps
  - ~70 users per beam with 600 kbps
  - ~50 users per beam with 800 kbps
  - <50 users per beam with 1 Mbps

- Overload conditions begin at about 3500-4800 packets / second
- Emulation performance is reached before satellite spot-beam capacity!

Emulated RTN link performance





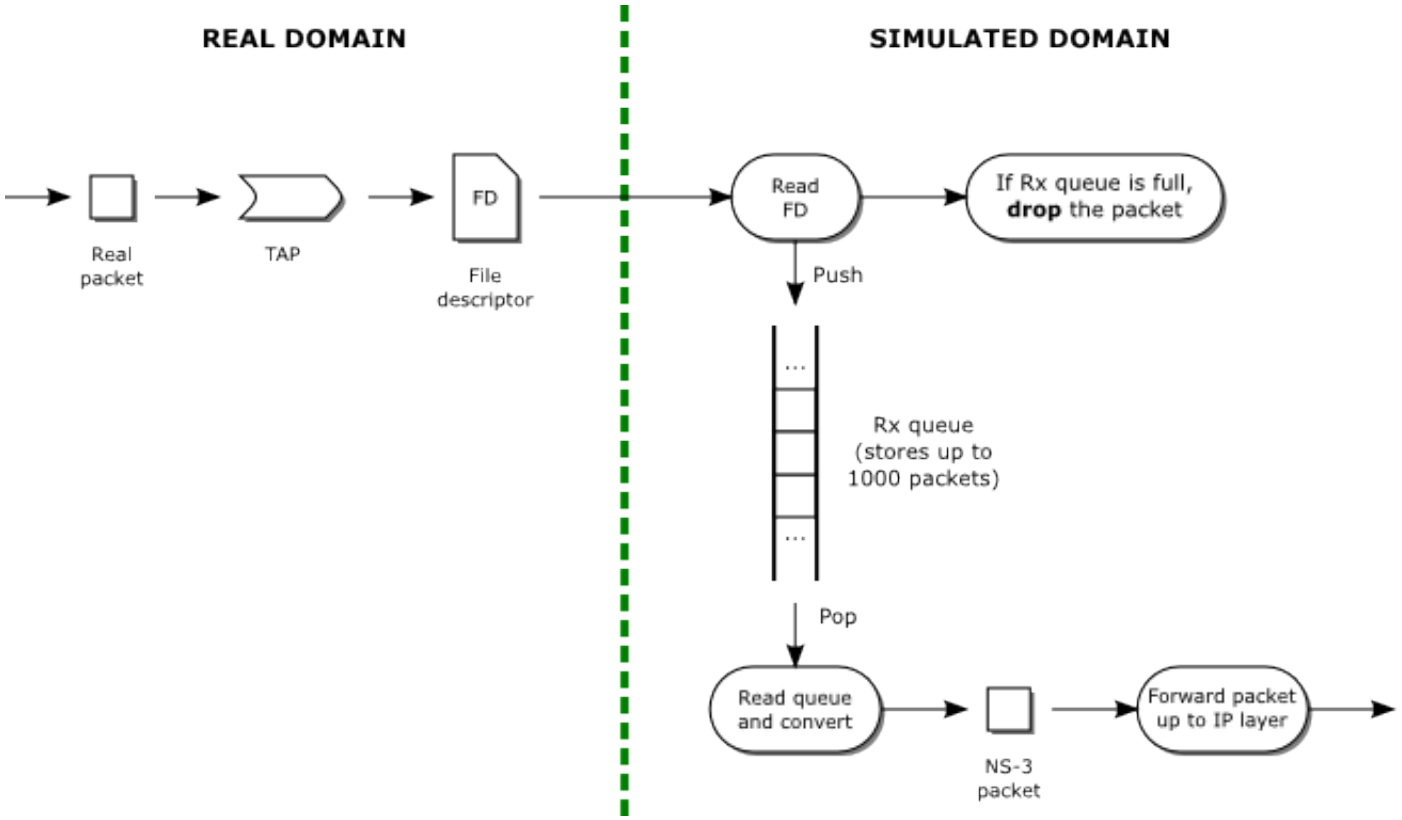
- Slightly higher emulation capacity than in FWD link
  - >110 users per beam with 200 kbps
  - >110 users per beam with 400 kbps
  - ~100 users per beam with 600 kbps
  - ~80 users per beam with 800 kbps
  - ~60 users per beam with 1 Mbps

- Higher complexity of the FWD link scheduler
- Emulation performance is reached before satellite spot-beam capacity!

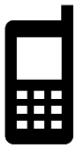
Emulation results analysis

- Much lower capacity with emulated cases if compared with fully simulated cases
- Emulation performance is reached before satellite spot-beam capacity!
- The simulator is not capable of converting the real packets to the SNS3 with enough speed, which results in (artificial) buffering delay and packet drops due to buffer overflow
- Emulation performance can be improved with
  - Better host computer performance
  - Parallellization of the simulator (usage of several threads)
  - Reducing the simulator complexity (amount of simulation events)
    -> improved implementation and/or simplified models

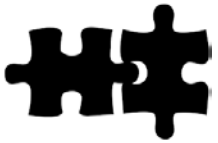
Emulation results analysis



Emulation use cases



- Application layer
  - More robust applications/services through testing in emulated satellite network
- Transport layer
  - Testing transport layer enhancements / new protocols
- Network layer
  - E.g. IP(v6) mobility, Multicasting
- Different devices
- Different OSs
- Distributed simulations?



Future work

- Maintenance and hosting of the SNS3
- Contribution of the code to ns-3 community
- Further development of SNS3 based on business needs

- ESA ARTES 5.1 AO 7476 “Network Security on Multi-Spot Beam Broadband Networks for Multicast Based Interactive Systems”
- ESA TRP AO8045 ”Robust TM System for Future Launchers”

Services

Services

SNS3 TRAINING

- We offer SNS3 training with tailored content for your requirements to boost your SNS3 project liftoff.
- Our trainings provided a requested share between theory and hands-on practice.
- Our certified trainers are experts in both different wireless technologies and simulation platforms.

SNS3 MAINTENANCE SERVICES

- We provide SNS3 maintenance services to support your satcom R&D.
- Maintenance includes SNS3 version upgrades, bug fixes, code improvements, testing services, and add-on tools.
- We provide development tools to provide modern, collaborative, additive and test-driven working environment.

SNS3 ADD-ON DEVELOPMENT SERVICES

- If some feature is missing from SNS3, contact our SNS3 team for a tailored, fixed price, quote with initial design steps, schedule and work hour estimate.
- We utilize agile software development to guarantee best end result and allow involvement and transparency for the customer.

SNS3 R&D SERVICES

- If you need simulative R&D support for your product development, network design or optimization, turn to our R&D services for both shorter term R&D support project quotes and longer term projects with continuity and fixed personnel.
- Our highly qualified team has a long experience in simulation driven R&D at industry, and an academic record with Ph.D. degrees and numerous international articles, IPRs and patents.

PARTNERSHIP

- If you need partners with simulative R&D expertise, for e.g. ESA or EU projects, please contact our SNS3 team!
- We have a strong competence in simulator design and development, in both terrestrial and satellite communication fields.
- We are experts in radio interface modelling, RRM algorithm design, verification and performance analysis.

Thank you for your attention!
Any questions?

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http://www.magister.fi
http://satellite-ns3.com

Additional slides

Frequency plan