

## NetBoxIT: an Open Testbed for Heterogeneous Networks Study



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- Introduction: Emergency Networks
- The FP7 Large Scale IP E-SPONDER
  - ✓ Vision
  - ✓ Network Architecture
- NetBoxIT: a modular, flexible, open framework for the study of heterogeneous networks
- Experimental results from the test-bed
- Conclusions





# FP7 Large Scale IP E-SPONDER

## Title:

A holistic approach towards the development of the first responder of the future

**Objective:** 

SEC-2009.4.2.1: First Responder of the future

## **Duration of the project:**

48 months (started July 1st 2010)







- FRs normally act either in remotely located areas with limited or disrupted communication infrastructures.
  - They need to exchange information with the Mobile Emergency Operation Centre (MEOC) and with the remote Emergency Operation Centre (EOC), to enable cooperation at all levels with the target to minimize the uncertainty typical of crisis events.



## The E-SPONDER Network Architecture

- Main backhaul link via satellite
- Extended area network (EAN), acts as a backbone for JANs
- Jurisdiction area network (JAN), fixed infrastructures, eventually used as backup backhaul links
- Incident area network (IAN), mesh network serving on-field FRs
- Personal area network (PAN), wireless sensors collecting environmental information







A vehicular communication infrastructure to support communications among FRs, other MEOCs, and the EOC

**Mobile Emergency Operation Centre** 

**Possible technologies:** 

- **DVB-RCS NG (main backhaul to the EOC)**
- WiMAX (inter-MEOC mesh)







# Possible Approaches for Performance Evaluation

#### Analysis: traffic theory

• Ideal but difficult for complex scenarios

#### Simulation

Pros: flexible, repeatable, cheap

Cons: huge amount of time and computing resources for complex scenarios, not so accurate and useful for implementation

### **Physical test-bed**

Pros: realistic Cons: expensive to deploy, not suitable for "a priori" evaluations

#### Hardware emulators

Pros: based on "ad hoc" devices: realistic and suitable for heterogeneous network studies Cons: expensive and usually not open to research community





# A modular & programmable framework



- as flexible as software simulator
- as modular as hardware emulator
- as realistic as physical test-bed

#### Our proposal:

hybrid approach, by using network emulators with virtualization techniques

We could virtualize each part of the emergency network using several simulators/ emulators and interconnect them through software entities





# Benefits of a hybrid approach







## NetBoxIT

**NetBoxIT** thought as trade-off:

- based on commodity hw
- "off-the-shelf" sw
- accurate modeling of networks
- support of real-time emulation
- modular: complex scenarios through combination of simple elements

#### Novelties:

- 1. Containers used to virtualize emulators and run several of them in parallel
  - Assign private CPU-corse to each emulator
- 2. Ethernet is used to bind emulators together and to external entities



a **netbox** represents a network portion created by running a network emulator within a dedicated virtual machine





# Which software tools ?



The wireless networks simulation: NS-3, one of the fastest simulators around, can also act as an emulator, allows real-world testbed integration

 Virtual Machines: traditional virtualization techniques allow to run several concurrent operating systems; examples: VmWare, VirtualBox, etc. This technique usually requires lots of computing resources

 Containers: light virtualization technique, allow to virtualize a whole operating system as well as a single application -Sun Containers, LXC

Why virtualization ? Using Containers/VMs we can assign to each NS3 instance a controlled amount of resources (CPU, memory, network interface, etc), as if NS3 was running on a different PC





# NetBoxIT is based on

- Hardware
  - > Dual Xeon Quad Core E5530 2.4GHz
  - > 8 physical CPU-cores (two CPUs with 4 cores)
  - > PCI-Express I/O bus
  - > 4 Intel Gigabit NICs

 802.11s
 SAT

 emulator
 emulator

 802.16
 3G

 emulator
 TETRA

 emulator
 Virtual Machine Host or Containers

 Hardware
 Hardware

- Software:
  - Linux 2.6 kernel
  - Linux Containers (LXC 0.7.4) to host
  - NS-3.9 emulators





## Heterogeneous network: the reference network scenario



**E** SPONDER

Run of several netboxes (networks) In parallel on a single platform

#### Components:

External PC: voice flow from FR Wi-Fi netbox: IEEE 802.11a FR-FRC WiMax netbox: FRC-MEOC link Sat netbox: return-forward channels External PC: EOC equipment



Network Segment	Technology	Distance	TX Power	Channel Model	Theorical Gross Capacity
FR-FRC	IEEE 802a	80 m	16 dBm	FRIIS	54 Mbit/s
FRC-MEOC	802.16 TDD 10 MHz @ 5 GHz	2.5 Km	30 dBm	FRIIS	Return/Forward Channel: 18/18 Mbit/s
MEOC-EOC	DVB-RCS-NG	76000 Km	-	ldeal: 254 ms latency	Return/Forward 2/10 Mbit/s

SEVENTH FRAMEW PROGRAMME

## Maximum IP goodput (return channel)



## NetBoxIT provides realistic results





# Traffic profiles and settings from FR/FRC to EOC

	Source rate (Kbit/s)	IP rate (Kbit/s)	Packet size
CBR VolP	16	48	74 bytes
CBR Video	388	401	256 bytes
CBR Data	272	305	256 bytes
Total	676	754	-

Settings for QoS on the WiMax segment

- VoIP managed with rtPS
- VIP with UGS (highest priority)
- Data as Best Effort





VIP vs. VoIP single flow







VIP vs. VoIP: 2 parallel flows



VoIP vs. VIP Latency

VoIP vs. VIP Jitter



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VIP vs. VoIP with 8 data flows





Bulk Data, VoIP, VIP Latency





VIP vs. VoIP with 8 data flows





FRC-MEOC distance increased to 7.5 km => maximum capacity = 775 Kbit/s 1 VIP + 2 VoIP + 8 data = 802 Kbit /s => WiMax link saturated

VIP flow preserved, VoIP flows degraded, data flows very delayed, as expected





# Conclusions



- NetBoxIT: test-bed for the study of heterogeneous networks
  - ✓ Linux containers
  - ✓ NS-3 as simulator/emulator
- It has been shown to be
  - Modular: several netboxes can be run in parallel with no penalities
  - Interoperable and real time: binding with real networks, devices and apps
  - Flexible: any kind of network can be emulated with NS-3 and virtualized
  - Open: use of Linux kernel 2.6, LXC and NS-3
  - Scalable: by assigning a CPU-core to every virtualized network
- Future works
  - ✓ investigating even more complex networks
  - ✓ analyzing other tools (i.e. netmap) for performance improvements
  - ✓ employment of software router, e.g. Click!,in the test-bed







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THANK YOU FOR YOUR ATTENTION

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... suggestions are very very welcome



