Towards Cognitive Host and Networks Mobility

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La Route Automatisée
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Outline

Outline

Research Scope and Objective

Mobile entities communicating with the rest of the world

- Mobile devices and vehicular networks
  - Mobile IP / NEMO
  - Multiple access media (MCoA)
- Two type of communications
  - with a remote host over a managed infrastructure (M/V2I)
  - with a similar peer over a self-organizing network (M2M/V2V)
    - Uncertainty of the trustworthiness of the self-organizing nodes
  - or combinations of both, M2M being the most general case

Research Scope and Objective

Characteristics of the communication

- Varying conditions along the end-to-end (unicast) path
  - Mobility-induced disconnections (how long before it should break?)
  - Improvement/deterioration of characteristics
    - Change of medium
    - Doppler effect? (unlikely)
    - Generic metrics: e2e goodput and delays
  - possibly changing rapidly
- Heterogeneous traffic
  - Infotainment: web, chat, VoIP, VoD
  - Traffic efficiency: driver/pedestrian advice
  - Traffic safety: road condition report, warning
  - Variable properties: priority, e2e requirements, adaptability, security

Research Scope and Objective

PhD objective

How to enable mobile communicating peers to make the best use of the network resources when they are available, and degrade gracefully when they are scarce?

Outline

Proposed Solution

Sensing, decision and adaptation

- Conditions sensing
  - locally
    - some relevant conditions only observable by other nodes of the NEMO such as the characteristics of the uplinks to the access routers or localisation information from an onboard sensors
  - along the end-to-end path
- Adaptable network stack components
- Valuation of the adaptable parameters of the network stack
  - based on priorities and requirements of the applications

Proposed Solution

Adaptable transport as an example of configurable stack component

- Cope with mobility-induced disruptions
  - Freeze-TFRC and adaptation into DCCP's CCID 3
  - presented in past Doctorades
- Adapt to changes to the end-to-end path
  - adjust internal parameters
  - signal the other end
  - idea to regulate TCP sender by adjusting ACK frequency (collaboration with Andrés Arcia)
- These solutions work better with external knowledge (A.K.A. cross-layer)
  - performance expectations based on lower layers' behavior
  - previously observed (or known) path characteristics
- $\Rightarrow$ need for an out-of-stack decision system

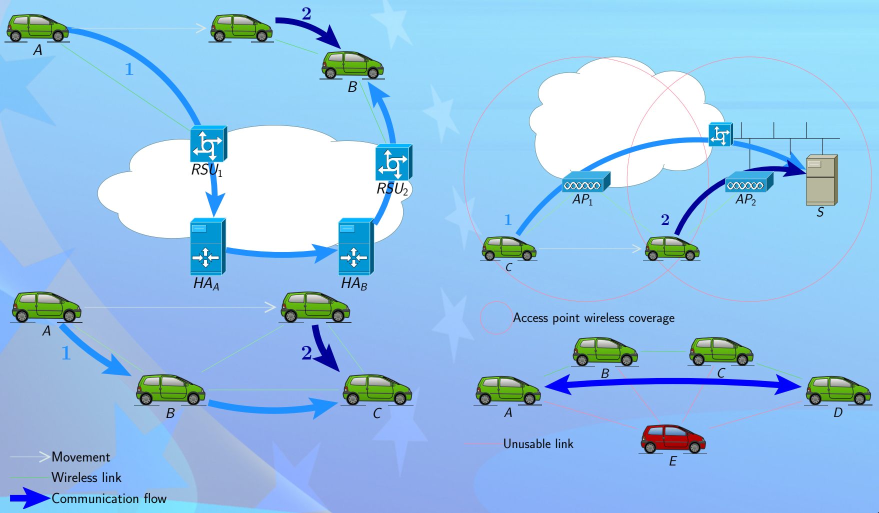
Proposed Solution

Cognitive Host an Network Mobility

- Inspired by Cognitive Radios and Networks
  - "intelligent" components that sense their environment and adapt accordingly
  - CRs: every node chooses the most appropriate frequency band and modulation
  - CNs: all nodes cooperate to select the best power, links and routes.
- Novelty of the approach: leveraging the mobility context
  - adaptation at all layers rather than the lowest ones only
  - not all nodes equipped (MR, HA, AR?)
  - interaction with other MR/MN better but not necessary
  - distributed sensing
  - information and policy exchange with the HA
- Node-local but stack-global decision
  - "Cross-Layer" design with contextual knowledge
  - Optimize stack parameters
  - Learning

Proposed Solution

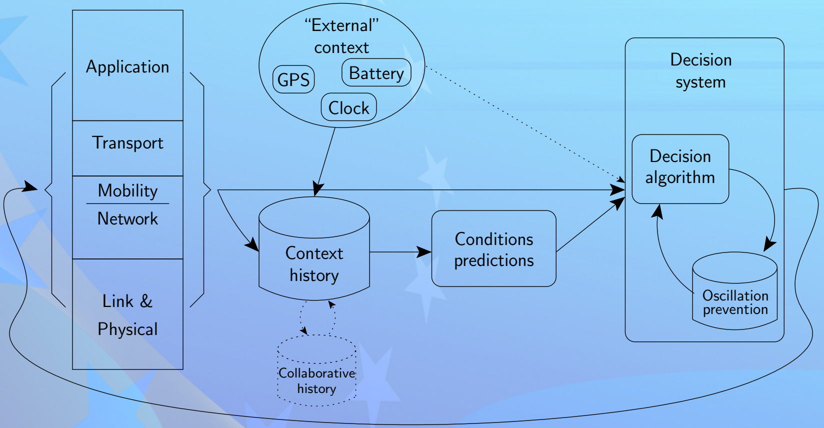
Example Target Scenarios



Outline

Cognitive Mobility

Framework for Observation, Decision and Action



Constraint-based Decision Algorithm

Motivation and basic idea

- Large configuration space → Combinatorial search techniques
- Modelled as a Constraint Programming problem
- The constraints solver unifies parameters to derive hints for the stack
  - Application quality: Qual($Quality$, $Throughput$, $Jitter$, RTT, PER)
  - Application socket: SocketDestination($Socket$, $Destination$)
  - Transport and routing conditions: Routing($Destination$, $Route$, $Interface$, $Throughput$, $Jitter$, RTT, PER)
- Variables to unify are
  - observed conditions on the links/networks/paths (offer)
  - possible configurations of the layers (demand)

Constraint-based Decision Algorithm

Example relations for a simplified model

Observed network performances

Destination	Route	Interface	Throughput	Jitter	RTT	PER
Addr1	NH2	eth0	2 Mbps	1×10^{-4} s	10×10^{-3} s	0%
Addr1	NH1	wlan0	900 kbps	1×10^{-3} s	100×10^{-3} s	10%
Addr2	NH1	wlan0	450 kbps	1×10^{-3} s	250×10^{-3} s	30%
			...			

Socket between applications and destinations

Socket	Application	Destination
1	App1	Addr1
	...	

Interface costs (switching + usage)

Interface	Cost
eth0	10
wlan0	100
ppp0	250
...	

Application App1 parameters and requirements

Quality	Throughput	Jitter	RTT	PER
1	$\geq$ 1.5 Mbps	$\leq 10^{-3}$	$\leq 10 \times 10^{-4}$ s	$\leq 10 \times 10^{-3}$
2	$\geq$ 1 Mbps	idem	idem	idem
3	$\geq$ 500 kbps	$\leq 10^{-2}$	$\leq 10 \times 10^{-3}$ s	idem

Constraint-based Decision Algorithm

Optimizing a cost function

- Parameter valuation trying to minimize a cost function *e.g.*

$$\min\left(\alpha \cdot rtt - \beta \cdot thr + \gamma \cdot C_{if}\right)$$

  - minimize *rtt*
  - maximize *throughput*
  - minimize interface cost

Constraint-based Decision Algorithm

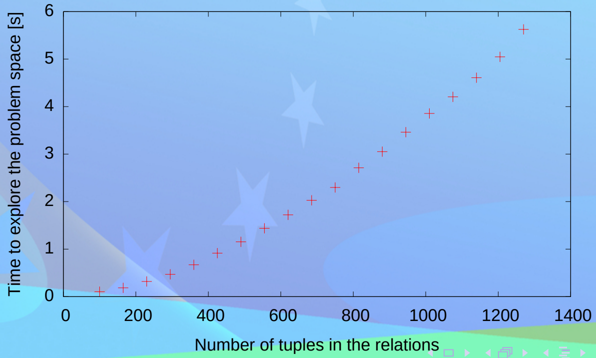
Core compononents under development

- Python/Netlink implementation under Linux
  - NETLINK_ROUTE, pushed by the kernel
    - link configuration parameters (RTMGRP_LINK)
    - neighbor information (RTMGRP_NEIGH)
    - interface addresses (RTMGRP_IPV6_IFADDR)
    - route information (RTMGRP_IPV6_ROUTE)
  - NETLINK_INET_DIAG, upon request
    - socket information
    - transport parameters
  - passing hints back to the stack to change parameters
    - Net100 network stack instrumentation for Linux
- MiniZinc Constraint Solver
  - current model similar to previously outlined
  - extended by history and cost relations
  - subject to change

Constraint-based Decision Algorithm

Timing evaluation of the solver

- CSP model randomly generated (max 5 interfaces, 190 destinations, 95 sockets)
- Coherent data (respecting ranges and correlations of parameters)
- 100 runs on an Intel Core2 Duo 2 GHz, 1 GB RAM
- All optimizations disabled → raw estimate of a higher bound



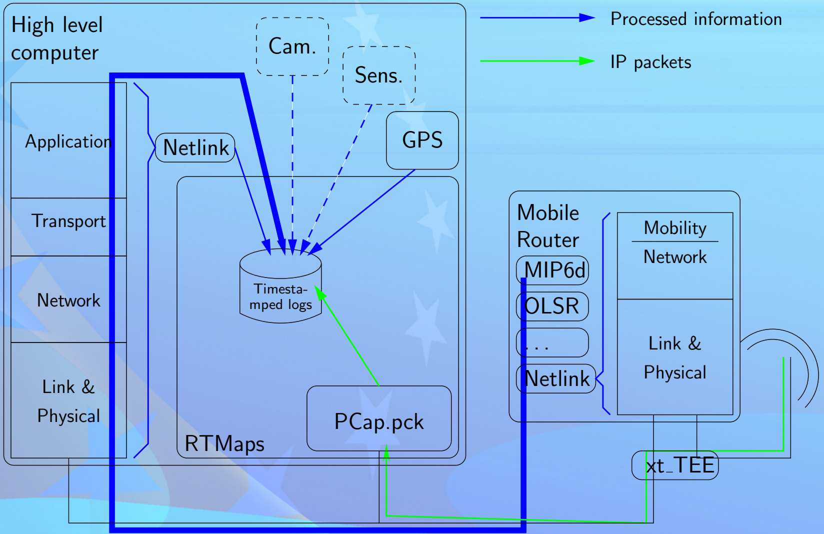
RTMaps-based Experimental Data Collection Platform

Using pre-existing systems to collect relevant data

- Need real data from a live stack to derive constraints further.
- Collect network information
  - Stack parameter set (state of relevant daemons)
  - Current performance
  - Network traffic (IP packets duplication based on xt_TEE)
- RTMaps
  - Rapid prototyping tool
  - Timstamped databases
  - Possibility to synchronise several hosts over a network
  - Already used for the rest of the in-car infrastructure
- Can be used both for data collection and future performance evaluation
  - *e.g.* data can be analysed using AnaVANET

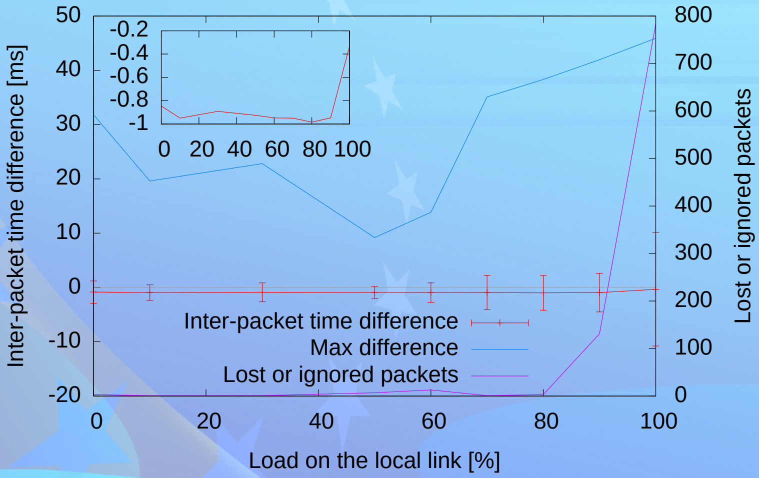
RTMaps-based Experimental Data Collection Platform

All data collection deported to the AU



RTMaps-based Experimental Data Collection Platform

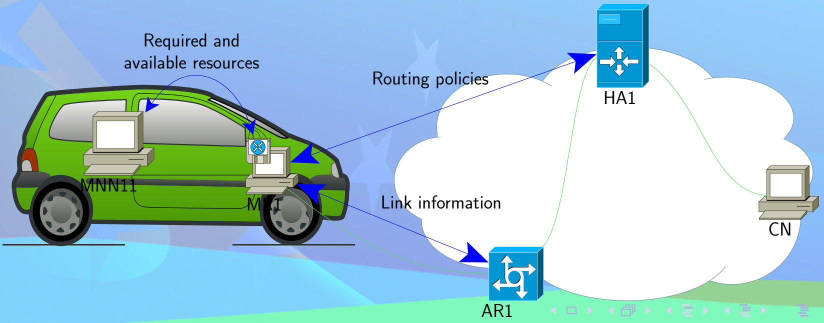
Impact of deporting the packet capture



Further Developments

Context Management Sytem for Information Exchange

- Several hosts involved to support mobility
  - MR, HA, CN, MNNs, AR
- Smarter and controlled parts of the network
  - Get the information where it is the most well known *i.e.* from its source rather than trying to estimate it
- Call for a distributed context-management system to easily share the information between more cooperative nodes (collaboration with Baptiste Gaultier)



Further Developments

Intregration within CALM

- CALM: Communications Access for Land Mobiles
  - ISO standard
  - Network architecture for terrestrial vehicles
    - Media-Independent Handovers
- Adequacy between the CALM Manager and the proposed framework
  - handles OSI communication layers
  - adpats reconfigurable stack parameters
  - manages the "local station", composed of hosts and routers, as a whole
- Will be implemented with the CALM interfaces in mind

Outline

Administrative Information

Contributions

- Adaptive transport: Freeze-DCCP
  - Olivier Mehani and Roksana Boreli. “Adapting TFRC to Mobile Networks with Frequent Disconnections”. In: CoNEXT 2008
  - Olivier Mehani, Roksana Boreli, and Thierry Ernst. “Analysis of TFRC in Disconnected Scenarios and Performance Improvements with Freeze-DCCP”. In: MobiArch 2009
- Cognitive NEMO
  - Olivier Mehani, Roksana Boreli, and Thierry Ernst. “Context-Adaptive Vehicular Network Optimization”. In: ITST 2009
- Experimental platform based on RTMaps
  - Manabu Tsukada, Olivier Mehani, and Thierry Ernst. “Simultaneous Usage of NEMO and MANET for Vehicular Communication”. In: TridentCom 2008
  - Current focus
- Other contributions:
  - Terence Chen, Olivier Mehani, and Roksana Boreli. “Trusted Routing for VANET”. In: ITST 2009
  - Ported various *ns* − 2 extensions (Freeze-TCP, MobiWAN, . . .)

Courses completion:

Advanced Networking (TELE9756) 6 UNSW credits, 33 contact hours, current result: 45%, simulations currently running for final assignment (worth 55%);

Nicta Short Courses 2 UNSW credits and 21 contact hours each,
- Network Simulation, assessment result: 95%;
- Network Analysis, assessment result: 100%;

Security Engineering (COMP9441) 6 UNSW credits, 60 contact hours, assessment result: 83%;

Universities requirements:

ENSMP 101/60 hours, 33 currently pending;

UNSW 10/18 credits, 6 currently pending.

Administrative Information

Roadmap

January 2010 RTMaps Experimental platform

February–May 2010 Cognitive NEMO

- **Feb.–Mar.** Local decision and adaptability
- **Apr.–May.** Distributed Context information within NEMO
- **Overall** Integration within CALM

June–End of 2010 Concluding work and dissertation writing

- Finish work on transports
- Experiments with the system
  - Mobile platforms at Nicta
  - Vehicles at Inria