Distributed Configuration and Load Balancing in Wireless Networks

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Outline

- Motivations and current work
- Self-configuring Access Points
- Load Balancing in wireless hotspots
- Monitoring of self-configuring devices
- Outlook

Why do we look at distributed configuration?

- Three main motivations:
  - Easy configuration in large networks
    - Boxes perform some configuration tasks autonomously
    - A central control is released from many tasks
    - → Reduce manual intervention where possible
  - Plug-and-play devices
    - New devices can be attached to an existing network
    - → Reduced costs of installation
    - → Possible new business models
  - Scalability
    - Distributed configuration can remove bottlenecks
    - Distributed algorithms might bring better performances

Distributed Configuration at NEC

- Distributed Self-Configuration of IP Routers (IP address space and Routing Protocols, not further addressed here)
- Self-configuring Access Points
  - Main goal is to support Plug-and-Play hotspots and network composition
  - Deployed generic architecture for a self-configuring device
  - Defined a model for information exchange between self-configuring APs
  - Analyzed information dissemination in large hotspot
- Load Balancing in wireless networks
  - Studied Load Balancing in 802.11e networks for a centralized approach
  - Currently adding load balancing to the distributed approach
- Generic monitoring of self-configuring devices
  - Main goal is to support self-configuring devices in operative networks
  - What do we need to monitor self-conf device?
  - Where are the bottlenecks in monitoring self-configuring devices?

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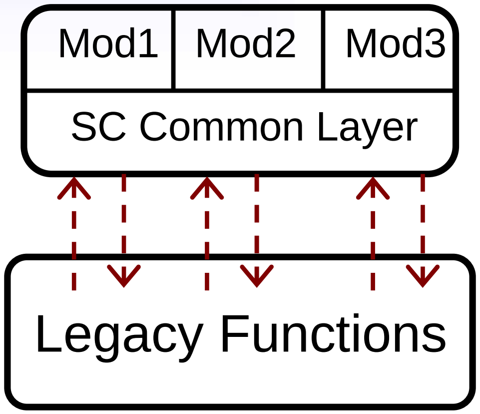
Self-configuring Access Points

- What is a self-configuring Access Point?
  - bootstrapping base station
  - can autonomously configure wireless properties
    - SSID, channel, protocol, TX power, etc.
  - can coordinate configuration with
    - neighboring stations
    - complete wireless network
- Configuration tasks are performed by different modules
  - A common layer provides basic functionalities (information exchange, timer…)
  - Each module runs specific configuration tasks
- An exchange protocol is used to synchronize information among stations
  - Synchronization can be performed
    - On periodic basis
    - Automatically after a configuration change
  - Information exchange is scoped
    - We can coordinate synchronization between neighbors and complete network

Behavior of a self-configuring AP



An extension for self-configuring is attached on a legacy device

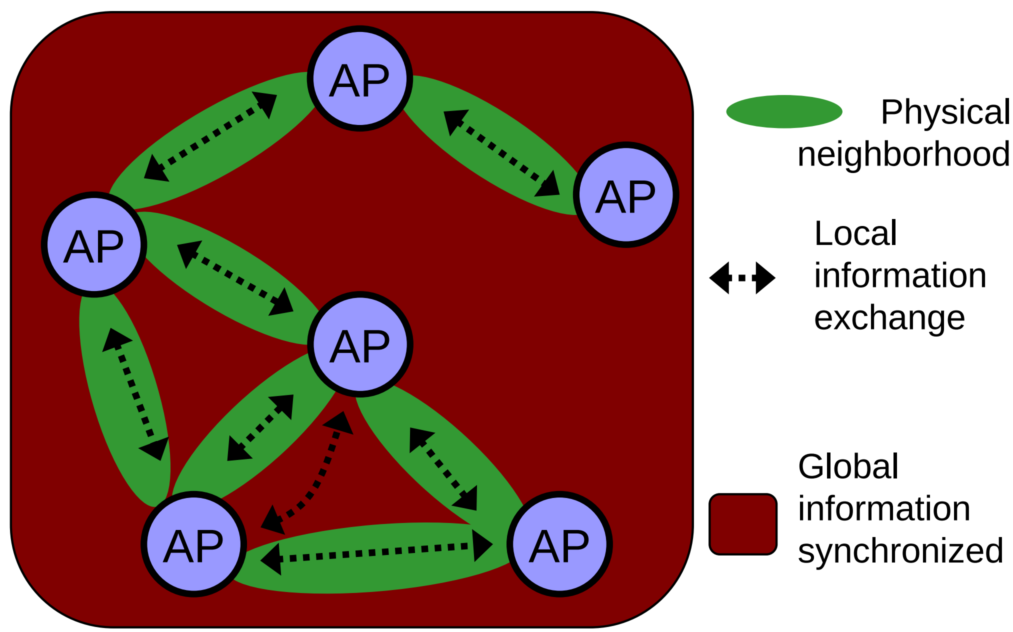
A configuration task is delegated to each module in the extension

Each module changes some configuration parameters

- On periodic basis
- Event based (e.g. after a configuration change)

A “neighboring” relationship between APs is established based on the physical topology

- Self-configuring APs can exchange information
  - On periodic basis
  - Event based
- Information is categorized on its scope
  - Private information
  - Local information
  - Global information



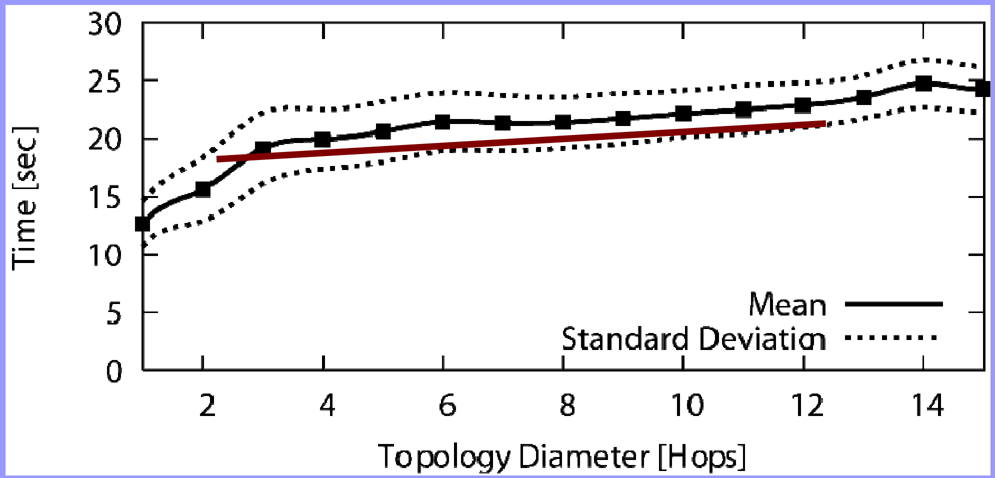
Configuration tasks

The following configuration tasks are supported:

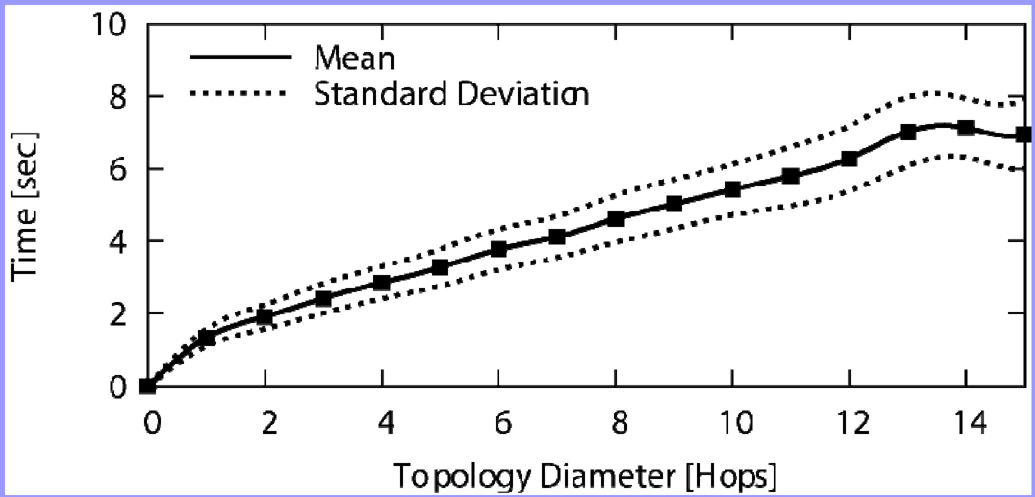
- SSID flooding
  - Goal: allow a station just plugged to enter into the existing BSS
  - Security can be achieved with certificates
- Channel assignment
  - Goal: reduce radio interference
  - Based on radio usage and local information an optimal channel is selected
- Load Balancing
  - Goal: maximize use of wireless resources and guarantee QoS
  - Overloaded AP can coordinate load with neighboring APs
  - Transfer from centralized LB
  - Still work in progress…
- …

Figures of synchronization between APs

Convergence Time for Initial Self-Organization



Spread Time of new Global Information



Main issues in self-configuring APs

- Neighborhood discovery
  - Neighborhood relationships are necessary for information exchange
  - Wireless scanning has some drawbacks (service interruption, no visibility)
- Bootstrapping
  - Desynchronization is needed to avoid inconsistent assignment
  - A random delay is added before bootstrap
- Joining an existing network
  - Some basic rules are employed
    - Bootstrapping AP imports global information from neighbors
    - An isolated AP loads a standard configuration
    - Administrator can manually overwrite some parameters
  - Clustering and merging of groups not investigated yet
- Versioning of global information
  - It avoids loops
  - It allows administrative actions
- Information updates
  - Event based updates might lead to instability
  - Periodic based updates might lead to inconsistent configuration
- Still some centralized bottlenecks resist (DHCP, AAA…)

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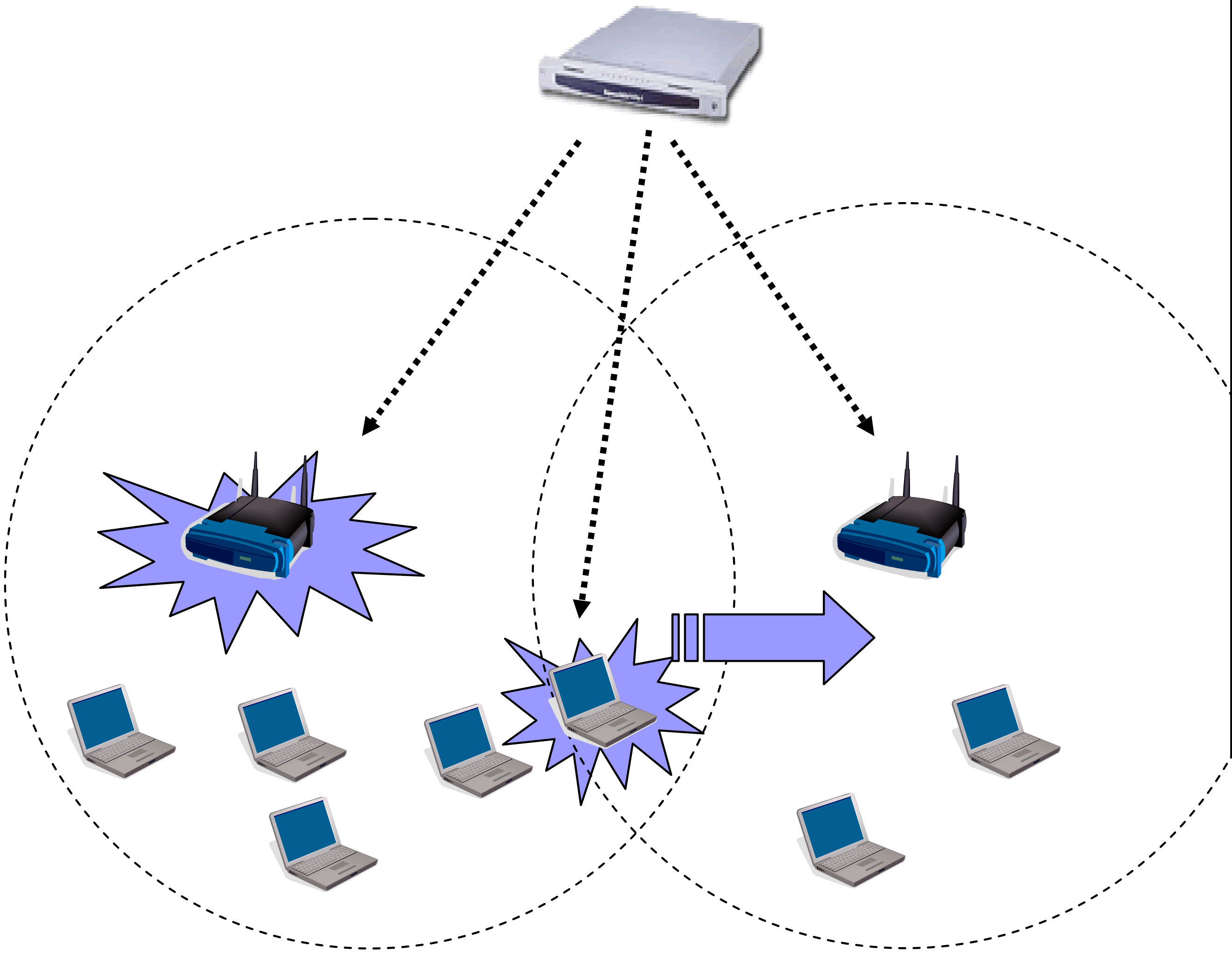
Load Balancing: general considerations



Questions:

What happens if there's not overlapping?

How do we control the terminal?

How do we know the position of the terminal?

Does the user receive better performances?

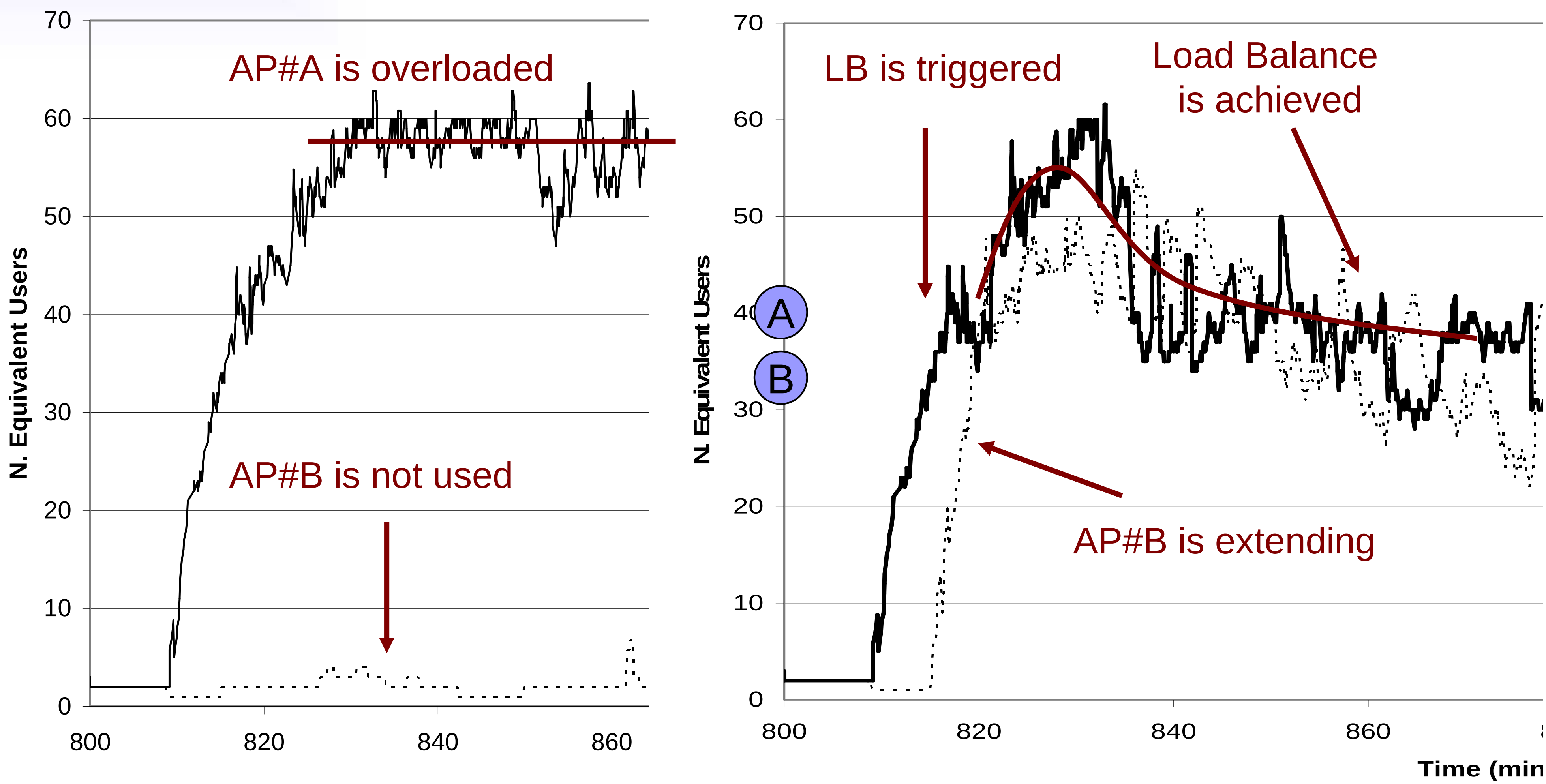
Is there service interruption?

How often we should move users?

Load Balancing: main issues

- Load Balancing can run with two goals:
  - Congestion Control
  - Load Balancing in general sense
- An algorithm controls load distribution
  - When an AP is overloaded
  - Which actions to undertake
- Architectural issues
  - How to measure users' load (measurement agent, profiles, counters…)
  - Performances at link level are relevant (in particular 802.11e QoS extensions!)
- Enforcement issues
  - How to enforce handover (L2 signaling, power control…)
  - We assume to control the load of a whole AP (not single user!)
  - In practical terms we refer to power control
- Performance metrics
  - Number of users accepted/rejected
  - Number of handovers

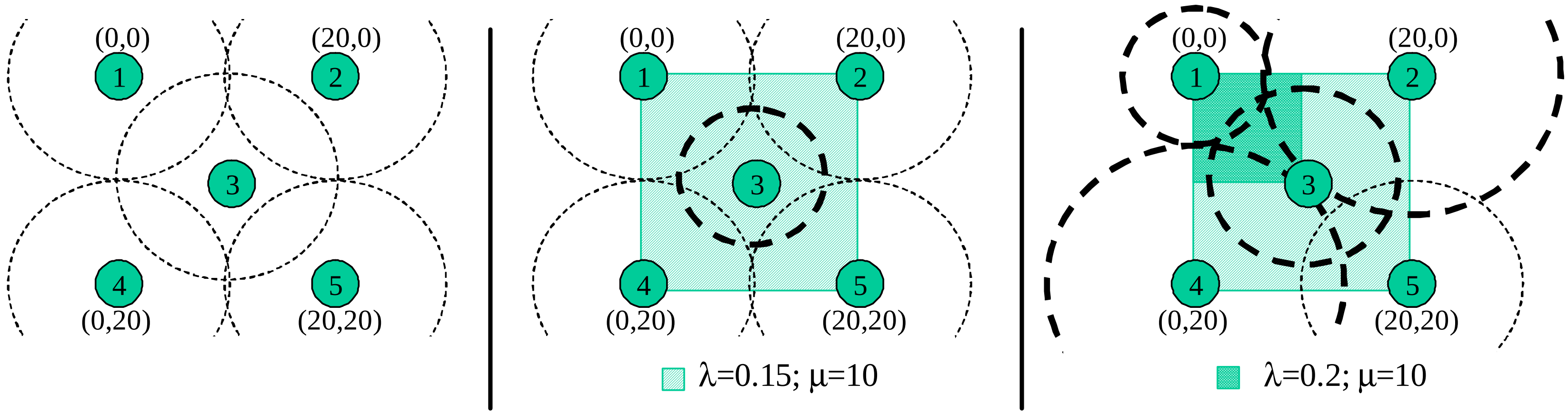
Results for centralized Load Balancing(1)



Two thresholds are controlling the behavior of the LB algorithm

A. Threshold to measure overload
B. Threshold to measure spare resource on neighboring APs

Results for centralized Load Balancing(2)



(a) Topology (b) Initial distribution (c) Second distribution

Users' distribution	Without load balancing		With load balancing (high threshold)		With load balancing (low threshold)	
	Rejections	Reassociations	Rejections	Reassociations	Rejections	Reassociations
100% BE	2,1%	---	0,03%	6%	0,68%	1,71%
90% BE - 10% VD	4,68%	---	2,38%	3,24%	5,1%	0,49%
60% BE - 40% VD	14,89%	---	8,24%	3,25%	7,66%	1,36%

Distributed approach to Load balancing

- Load balancing is based only on current status of neighboring APs
- Load balancing can be supported in the current architecture of self-configuring APs
  - Current load of APs need to be exchanged among APs
  - The same algorithm can be applied
  - How often the information is exchanged?
    - On reaction of a change of the load → overhead?
    - On periodic basis → loss of performances?
- Load balancing will be a good reference to measure different performances of distribute management
  - Performance metrics of service (accepts, rejects, handover…)
  - Effects of synchronization on the management task
- Results need an extension to current simulator

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Motivations to monitor of self-configuring devices

Barriers to deployment of self-configuring networks

Technical risks:

- Not optimized software
- Traffic overhead
- Loops in propagation
- Too frequent changes
- Oscillations

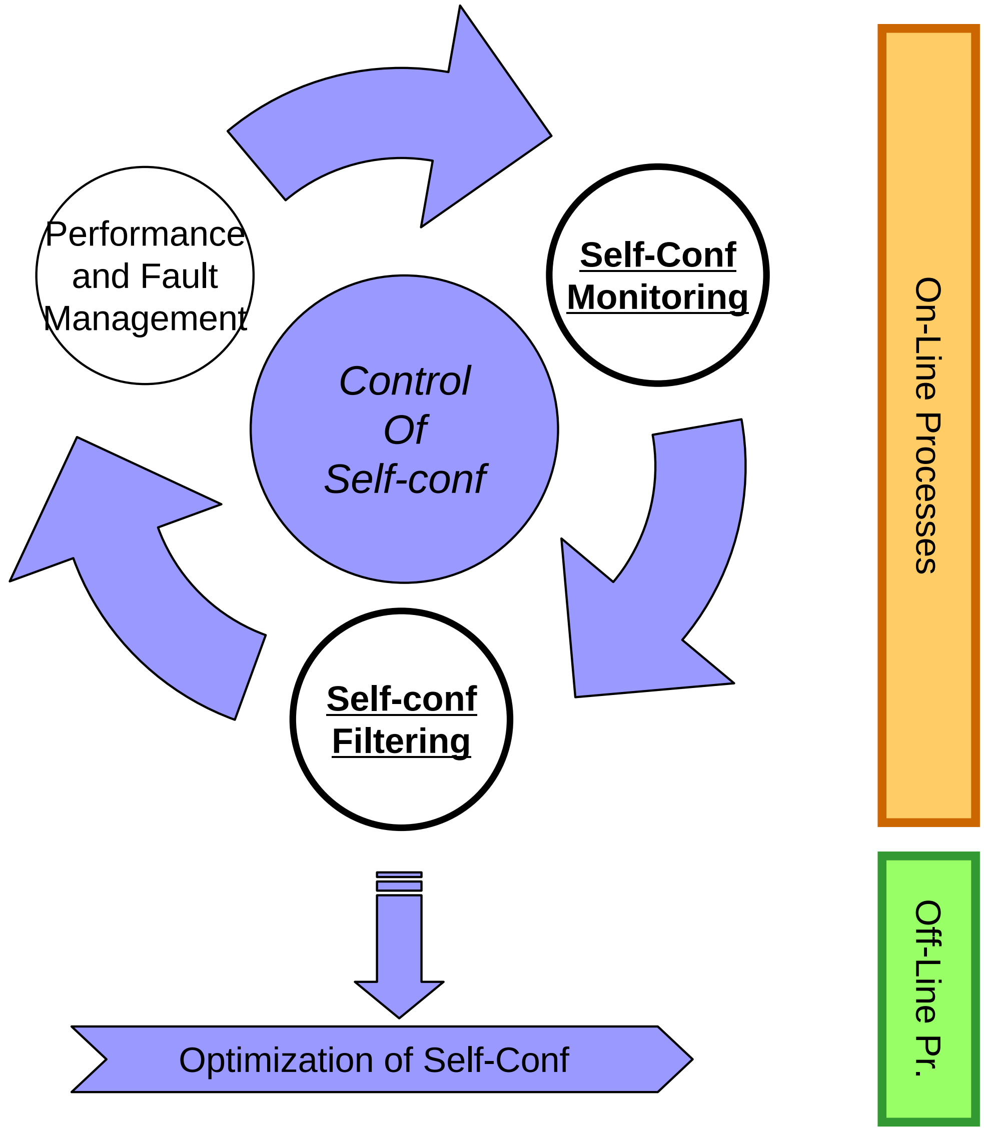
Operators' skepticism:

- Possible need to know what is happening
- "Mental wall" against uncontrolled delegation to devices

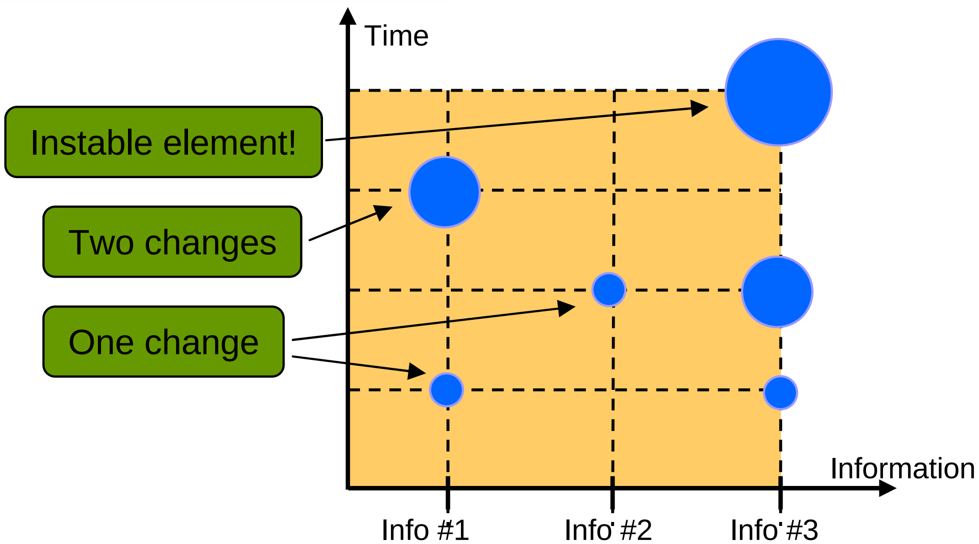
Need to define a monitoring framework for self-configuring networked devices!

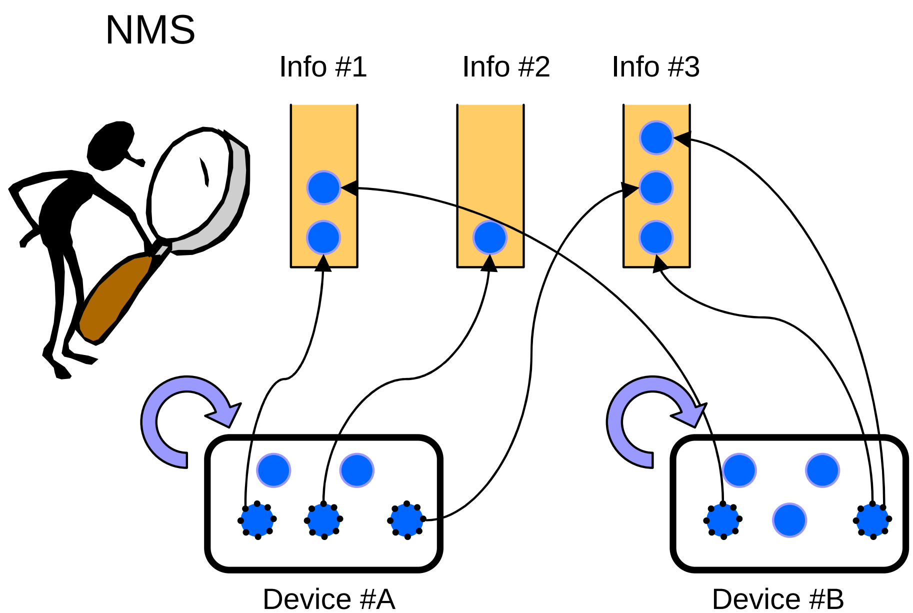
Integration into Management Processes

- Motivations:
  - Distributed approaches must be integrated into existing processes
  - A monitoring framework is needed to support them in operative networks
- Main idea:
  - To deploy a tool to monitor change of configuration and information exchange
  - Support limited capability to filter configuration tasks in case of failure



Monitoring changes





- Monitoring station sees
  - The information changed
  - The triggers changing the information
- By collecting the tokens of changes it is possible the measure the frequency of changes

The SCM MIB module

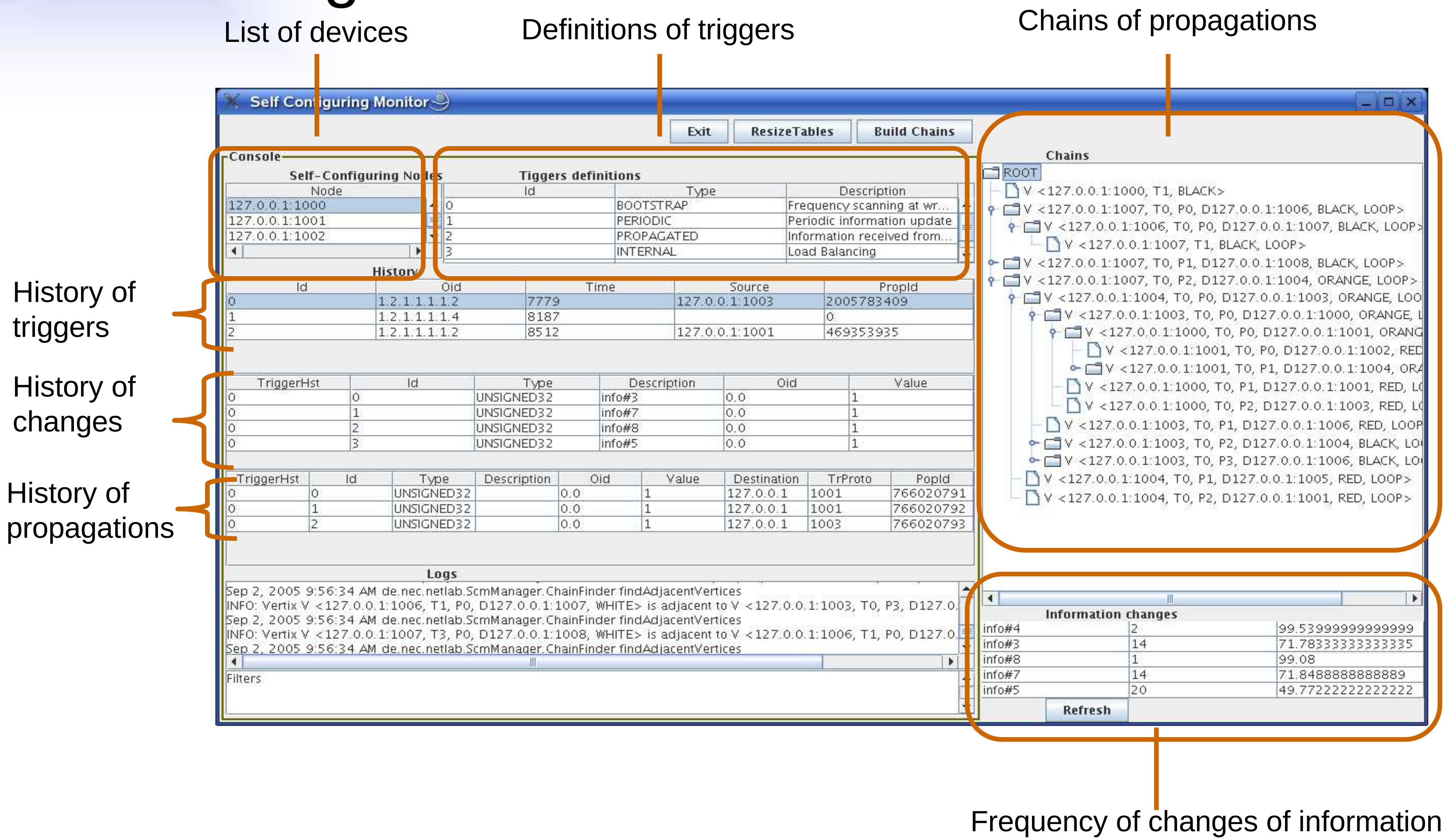
Implementation deployed with the SNMP framework
- SNMP is already widely deployed in existing devices
- SNMP can be easily used for monitoring

Mapping of the information model to a new MIB module
- A table lists the triggers defined by the self-configuring applications
- Three tables trace the history of the decisions made by the applications
- A table stores the filters of the triggers
- Notifications of changes can be sent to the monitoring station
- Information elements can be mapped to Object Identifiers (OIDs)

MIB Module

+ ScmModule
  + TriggersDef
  + History
    + HstTriggers
    + HstInformation
    + HstPropagation
  + Filters
  + Notifications

Monitoring Station



Summary

- Distributed configuration of wireless networks revealed to be feasible
- Load balancing will be an interesting field for comparison
  centralized ↔ distributed
- A monitoring framework can support self-configuring networks in operative scenarios
- The behavioral model behind the monitoring framework is consistent with the architecture of self-configuring APs
- Integration of the work done until now would give better evaluation of pro/cons of self-configuring networks

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