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Policy-based Management of Wireless Ad hoc and P2P Networks

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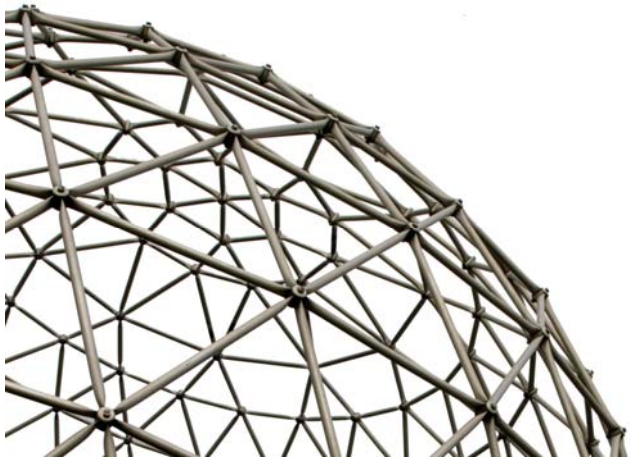

Outline

- **Introduction and Motivation**
- Self-Management Framework
- Framework Evaluation
- Conclusions and Discussion

Introduction and Motivation

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- HOW ad hoc networks relate to P2P ?
- WHY use Policy-Based Management ?

Introduction and Motivation

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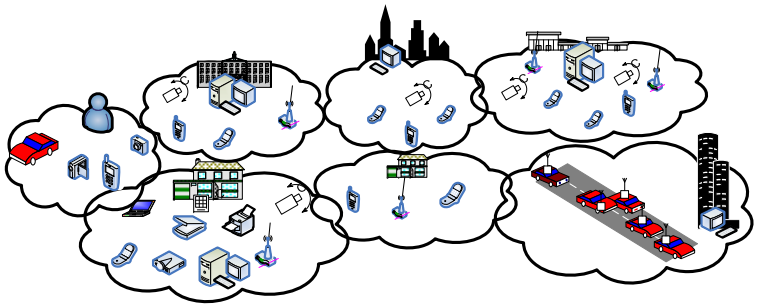
- WHERE do we have wireless ad hoc networks ?
  - Military , disaster relief …
  - *BUT* not only (!)
  - Ad hoc networks are (*potentially*) **everywhere**

  → 802.11 IBSS mode (a.k.a. **ad hoc/p2p**)
  - Users can create an ad hoc network on the spot
    - Laptops, PDAs, smartphones etc…
    - Single-hop and fully-connected
- WHY do we need them anyway ?
  - Deploy applications and services
    - E.g. disseminate all workshop material in p2p manner

Introduction and Motivation

- Ad hoc for wireless networks can have the analogous potential of P2P for fixed networks
  - if they are easy to setup and use
  - if they are secure and reliable
- Mobile Ad Hoc Networks (MANET)
  - Research emphasis on routing and analytical models
  - Lack of realism in research → negligible market impact
  - *BUT* wireless Ad Hoc is ubiquitous → 802.11 IBSS mode
- **Hybrid ad hoc networks**
  - MANET with infrastructure support
  - Multi-hop wireless / Mesh networks
  - Spontaneous/nomadic computing



Introduction and Motivation

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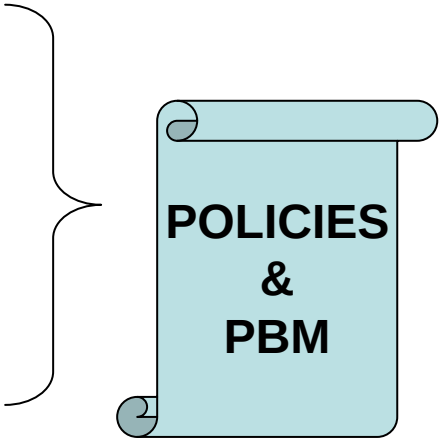
- Issues and problems with ad hoc networking
  - PHY: Air interface prone to interference (ISM band)
  - MAC: Hidden/exposed Terminal, lack of AP coordination
  - Network: Multi-hop routing, IP addressing
  - Transport: TCP poor wireless performance (congestion control)
  - Application: *Default* settings not optimal
- *Proposal*: Self-management/autonomic solutions
- Starting from lower layers : MAC/PHY
  - Interference: significant factor for reduced performance
  - Regulatory issues ignored (regional differences)
  - Auto-configuration not taken for granted

Introduction and Motivation

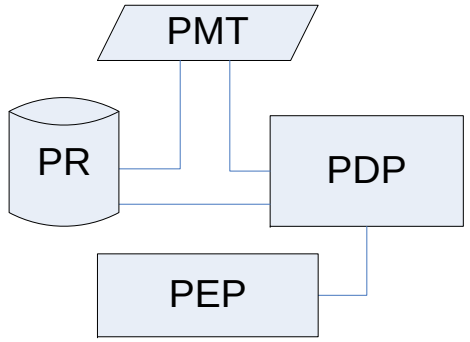
- Self-Management and Autonomic Computing
  Self-* Capabilities to achieve Self-maintenance
  +Self-Configuration +Self-Healing
  +Self-Optimization +Self-Protection

- Proposed Solution
  - Assist devices in self-* decisions
    + Self-Configuration
    + Self-Optimization
    + Regulatory conformance
  - Evaluate conditions and reconfigure



Introduction and Motivation

- Why Policy-Based Management (PBM)?
  - High-level policies simplify complex tasks
  - Low-level policies implement objectives
    Event-Conditions-Actions
  - Controlled programmability
  - *BUT* typically centralized

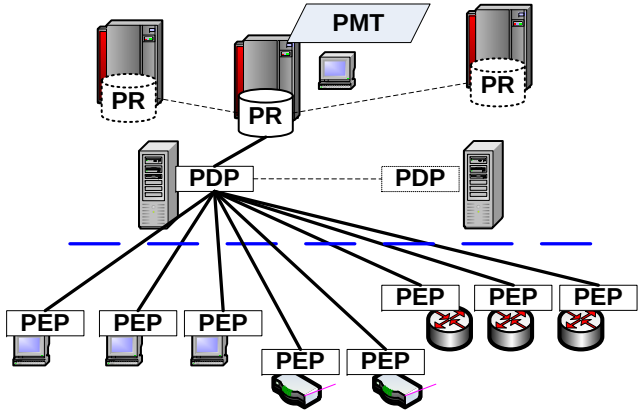


- Self-* ***Vs*** PBM or Self-* ***with*** PBM ?
  - Distributed Policy Repository
  - Policies as guidance not as directives
  - User-owned networks → no strict admin control

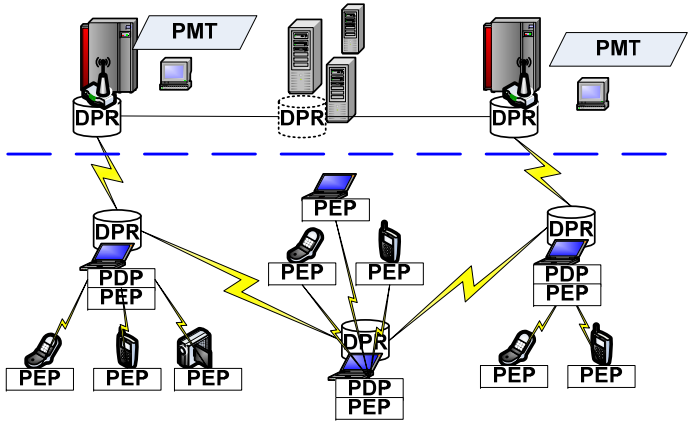
- Introduction and Motivation
- **Self-Management Framework**
- Framework Evaluation
- Conclusions and Discussion

Self-Management Framework
Distributed Policy Repository

- Policy Repository
  - Critical functional element of PBM
  - Encapsulates management logic
  - Resides in core network
  - Replicated for resilience

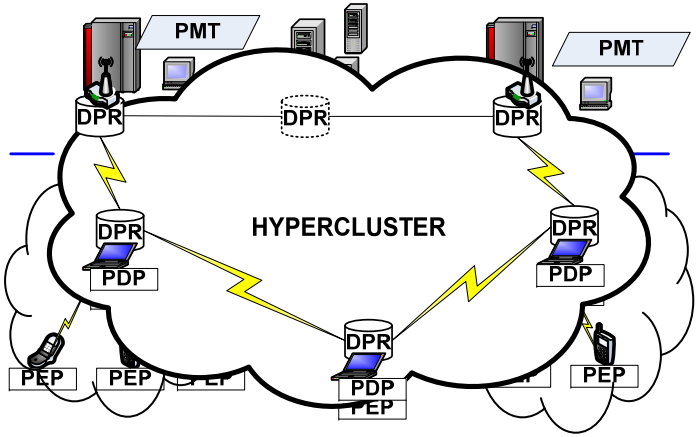


- PR for wireless ad hoc networks → **DPR**
  - PDP intermittently connected
  - Multi-hop routes degradation
  - PDP population may fluctuate
  - Increasing heterogeneity
  - Clustered ad hoc networks



Self-Management Framework
Distributed Policy Repository

- Management of clustered ad hoc networks
  - Cluster Heads host a PDP
  - PDP spatially dispersed
  - Enforcement in own Cluster, i.e. local PEPs
- Coordination of PDP
  → **Hypercluster**



- Problem transformed: deployment and maintenance of distributed repository replicas
  - DPR propagation of policies to PDP
  - PDP pull-based retrieval
  - Loose replication based on LDAP
    → P2P overlay

Self-Management Framework for dynamic channel configuration

- Event-Condition-Action (ECA) sets of policies
  - *Events* examine desired notifications
  - *Conditions* evaluate wireless channel
  - *Actions* ensure regulatory conformance
  - *Actions* select optimal channel for deployment
  - *Actions* reconfigure channel for optimized perf.

- Regional Spectrum Regulations
  - Deploy ad hoc network only on allowed channels
  - End-users unaware (default settings)
  - E.g. 802.11b/g: Pi:list1 = 1..11 and Pii:list2 = 1..13.

P#	*Event*	*if {Conditions} then {Actions}*
i	SystemBoot	if {region=FCC} then set_criteria(approvedChannels[$list_1$])
ii	>>	if {region=EU} then set_criteria(approvedChannels[$list_2$])

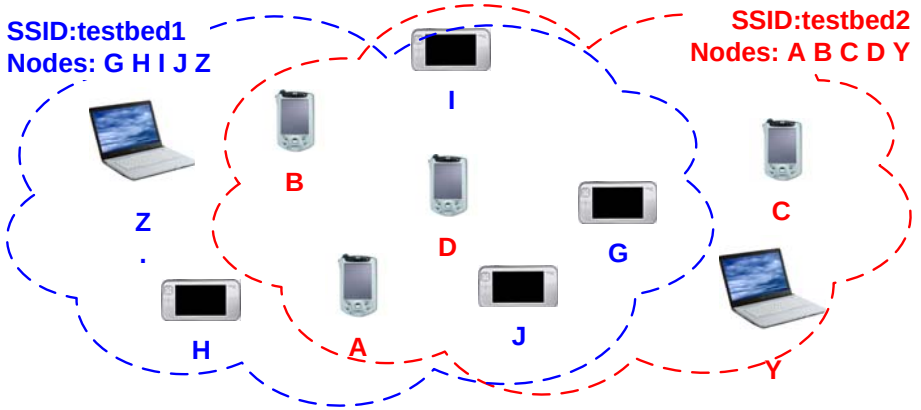
Self-Management Framework

P#	*Event*	*if {Conditions} then {Actions}*
1	Init_new_adhoc	if {ready} then {scanChannels()},{generateScanComplete(results)}
2	ScanComplete(results)	if {otherWLANdetected=true}^{FC:=freeChannels(results), FC=true}^{PC:=preffered(FC,*ch_list*),PC=true} then {optimizeChannel(PC,$algorithm_1(criteria_1)$)}
3	>>	if {otherWLANdetected=true}^{FC:=freeChannels(results), FC=true}^{PC:= preffered(FC,*ch_list*),PC=false} then {optimizeChannel(FC,$algorithm_2$(criteria$_2$))}
4	>>	if {otherWLANdetected=true}^{FC:=freeChannels(results), FC=false} then {optimizeChannel(all, $algorithm_3$ ($criteria_3$))}
5	NewWLANdetected	*if* {*dyn_adapt*=true} *then* {generateStartAdapt(newWLANinfo)}
6	LinkQualityCheck	if {LinkQuality<thr_a}^{*dyn_adapt*=true} *then* {generateStartAdapt(cachedWLANinfo)}
7	StartAdapt(WLANinfo)	if {channel_distance(WLANinfo,current) < *dist*} ^{*app_specific_metric* < thr_b} *then* {scanChannels()},{generateAdaptChannel(results)}
8	AdaptChannel(results)	*if* {results_evaluation()=true} *then* {channel_switch(all,$algorithm_4(criteria_4)$)},{verify()}

- Introduction and Motivation
- Self-Management Framework
- **Framework Evaluation**
- Conclusions and Discussion

Framework Evaluation Testbed

- Hardware
  - 10 wireless nodes
  - Internal 802.11b/g
  - External PCMCIA
  - IBSS (a.k.a. ad hoc/p2p)



- Software
  - wireless-tools (configure interfaces) → using scripts
  - airodump-ng (capture packets) → custom version for PBM
  - scratchbox (cross-compile source) → for use with ARM proc.

	Operat.System (Kernel)	*Processor*	*Ram (MB)*	*Wifi support*
(2x)Sony Z1XMP	**Debian R4.0 (2.6.18)**	**1500 - Intel**	**512**	**802.11bg**
(4x)HP iPAQ H5550	**Familiar v0.8.4 (2.4.19)**	**400 - ARM**	**128**	**802.11b**
(4x)Nokia N800	**IT OS2007 (2.6.18)**	**330 - ARM**	**128**	**802.11bg**

Framework Evaluation Testbed

- Setup in two ad hoc clusters
  - Ad hoc file transfer within clusters
    - First cluster used PBM support
    - Second acted as interfering WLAN
- Cluster Head can monitor and assess air interface
  - Extracts MAC header (L2) information
    - RF-monitor mode *or* Promiscuous mode
  - Uses custom packet capturer
    - Modified airodump-ng source
  - Channel selection algorithm
    - Weighted Average WA(x)
    - Metric **x**: missed frames, avg.pps etc.
  - Closed control loop
    - Inter-layer communication provides feedback

Framework Evaluation
Self-Configuration

- Self-configuration of initial ad hoc deployment
  - 20.4% increase of average goodput compared to default settings
  - Up to 33.3% increase for random channel assignment
  - Worst performance for consecutive channels
  - File download duration is accordingly improved

testbed1, 2 (channel)	Goodput *testbed1*(Mbps)	Goodput decrease (%)	Downl.Time increase (%)
1,1	3.48	-20.38	+20.00
2,1	2.92	-33.27	+46.67
4,1	4.26	-2.68	0.00
6,1	4.38	---	---

Framework Evaluation
Self-Optimisation

Ph.1: file transfer Z→J (ch.1)

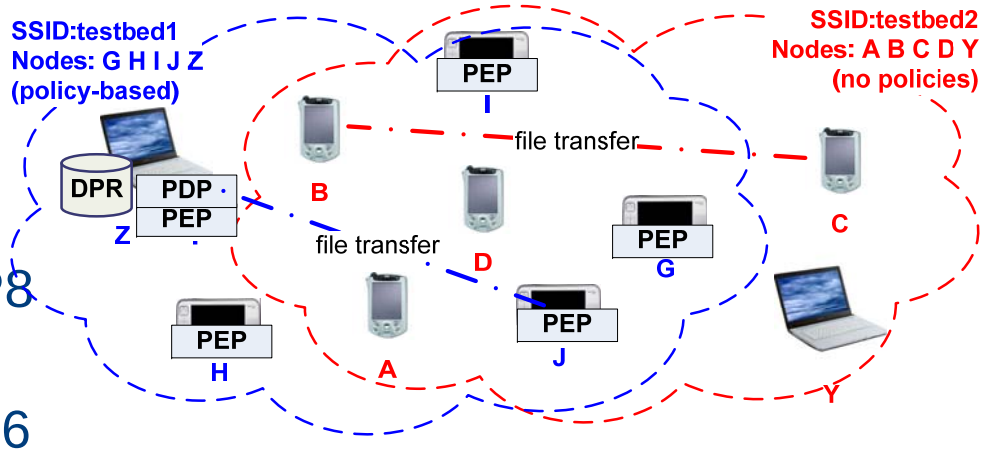
Ph.2: file transfer B→C (ch.1)

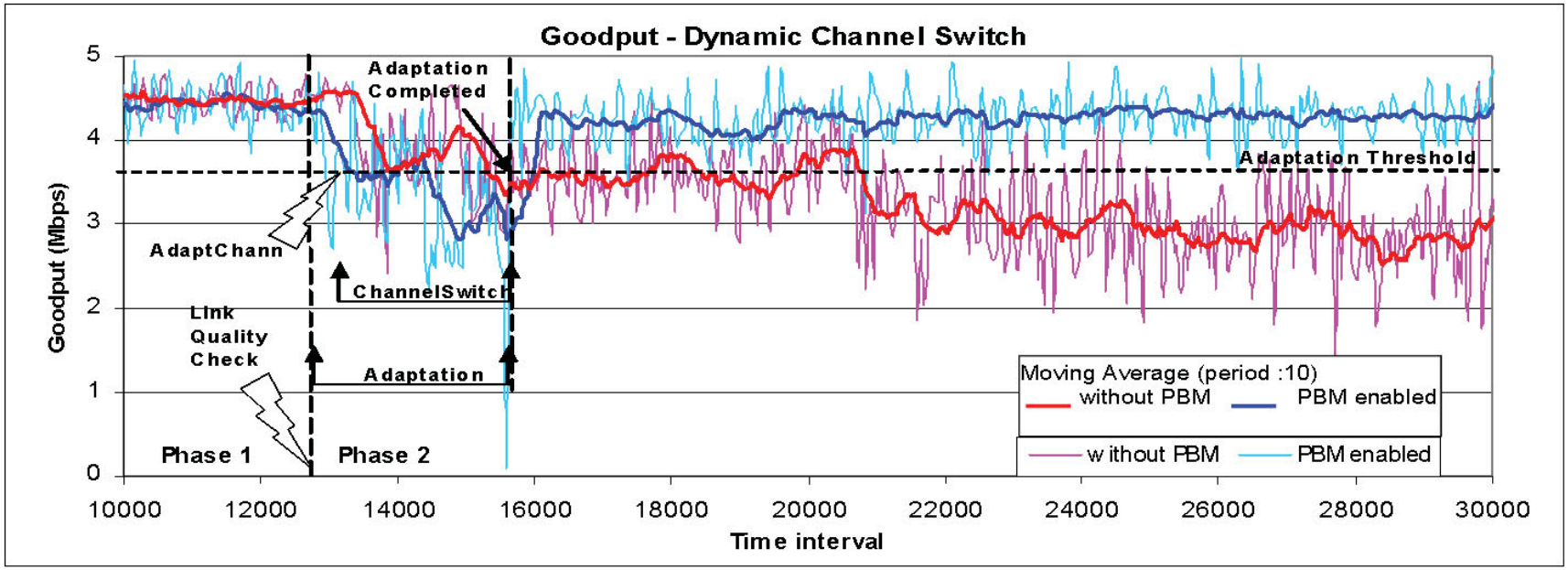
P6: LinkQuality:thr_a <50% ➔P7

P7: Goodput:thr_b <3.67MBps ➔P8

P8(AdaptChannel):algorithm

➔channelSwitch: from ch.1→ch.6





- Introduction and Motivation
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- **Conclusions and Discussion**

Conclusions and Discussion

- Tangible performance improvement

+ Self-optimization with dynamic channel switch
  + Peak increase of 33.5%
  + Average goodput increase by 20.3%
    - from 413.54 KB/s to 518.79KB/s
  + Download time reduced
    - from 116sec to 50sec for a 46MB file

+ Self-configuration of initial ad hoc deployment
  + Up to 33.3% increase for random channel assignment

+ Regulatory conformance of ad hoc networks

Conclusions and Discussion

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- HOW ad hoc networks relate to P2P ?
  - single-hop P2P using 802.11 IBSS (ad hoc mode)
  - P2P overlays over multi-hop ad hoc networks
- WHY use Policy-Based Management ?
  - PBM and policies as middleware
  - Controlled programmability
  - Future-proof solution
    - Technology-independent specification
    - Technology-dependent enforcement

Conclusions and Discussion

Open Research Issues

Related to PBM and policies

- Translation and refinement
- Conflict detection and resolution

Related to wireless ad hoc and p2p networks

- Multi-hop and large-scale deployment
- P2P-aware routing protocols for ad hoc
  - Cross-layer / inter-layer (e.g. MPP)
- Suitable storage and distribution of PR
- P2P organisation of ad hoc networks (*hypercluster)*
- ***Security***

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Questions and Discussion

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