

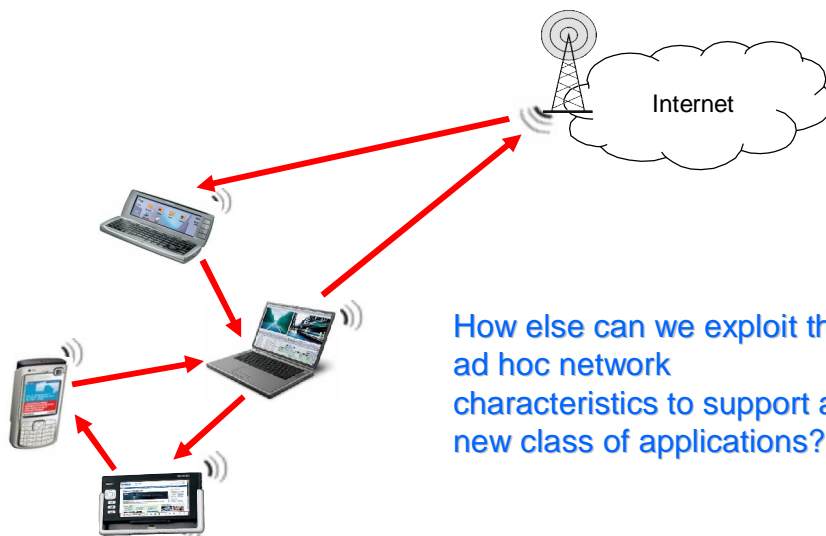
Context-aware Migratory Services in Ad Hoc Networks*

Rutgers-Helsinki Ph.D. Student Workshop on
Spontaneous Networking
8-12th May 2006

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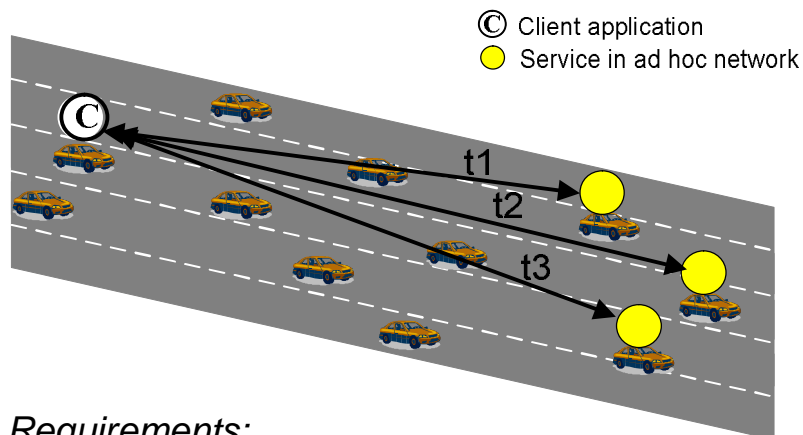
Connecting to Internet through ad hoc networks



Ad hoc networks as service providers

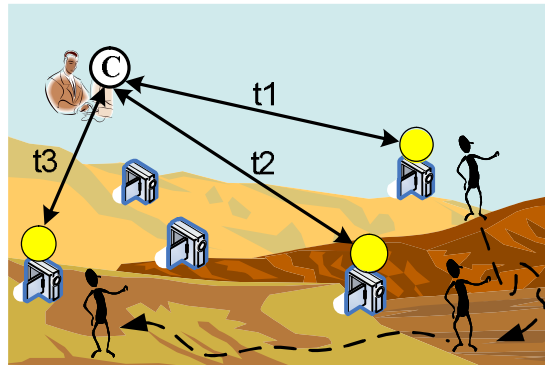
- ü Enable a new class of services specific to ubiquitous computing environments
- ü Acquire, process, disseminate real-time information
- ü Targets: region, activity, entity

Traffic Information from region at constant distance in front of the driver



- ü *Requirements:*
 - *Service must be aware of its context*
 - *Service must adapt to user's context*

Entity Tracking Service



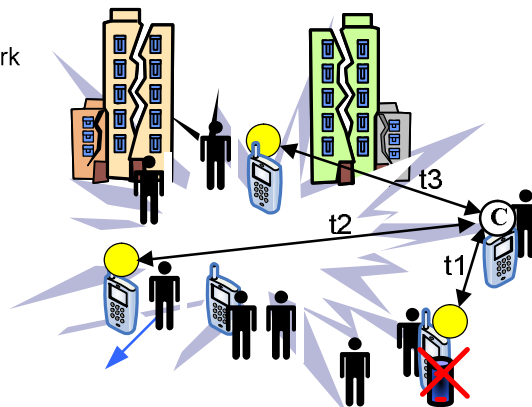
© Client application
● Service in ad hoc network

Requirements:

- Service must be aware of its target
- Service must preserve its execution state over time

Spontaneous Monitoring Service

© Client application
● Service in ad hoc network



Requirements

- Transfer code from node to node
- The service must be aware of its context

Requirements for services in ad hoc networks




- ü Context-awareness
 - dynamism of services and request targets
- ü User-driven adaptability
 - dynamism of user needs and operation
- ü Service continuity
 - due to context changes, nodes may become incapable of hosting services, and stateful interaction
- ü Demand code distribution
 - nodes do not possess the code for any type of service

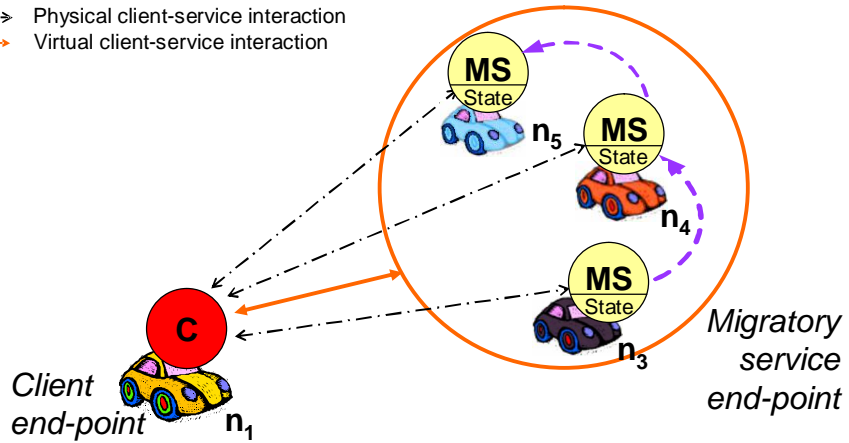
How can we enable such services?

Outline

- ü Motivations
- ü Context-aware Migratory Services
- ü Migratory Services Framework
- ü Evaluation
- ü Conclusions & Future Works

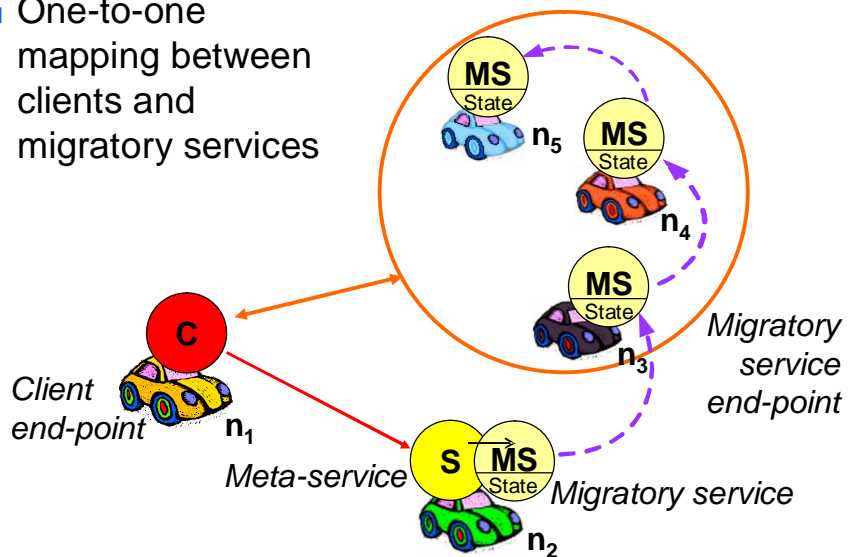
Migratory Services Model

-  MS migration
-  Physical client-service interaction
-  Virtual client-service interaction

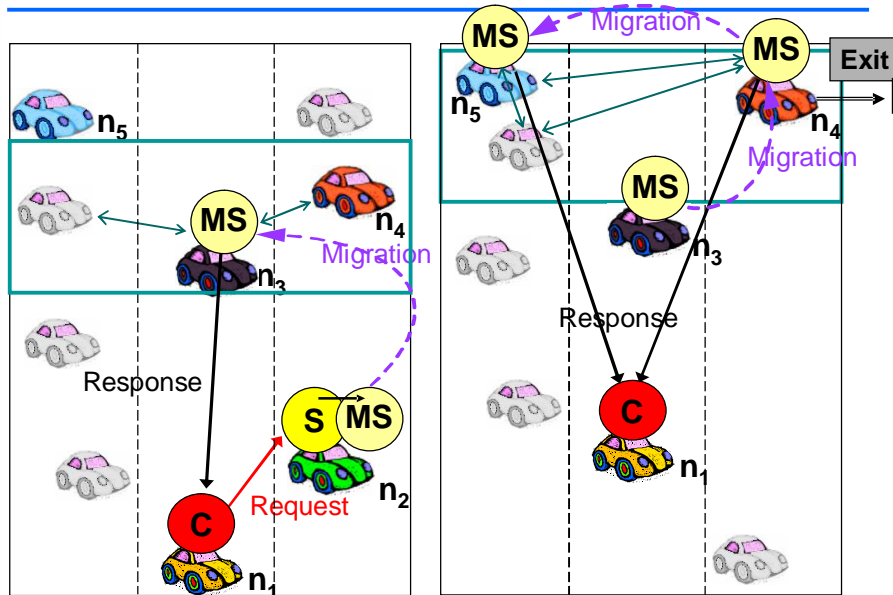


Migratory Services Model - cont'd

- ü One-to-one mapping between clients and migratory services



Example: Region monitoring Service



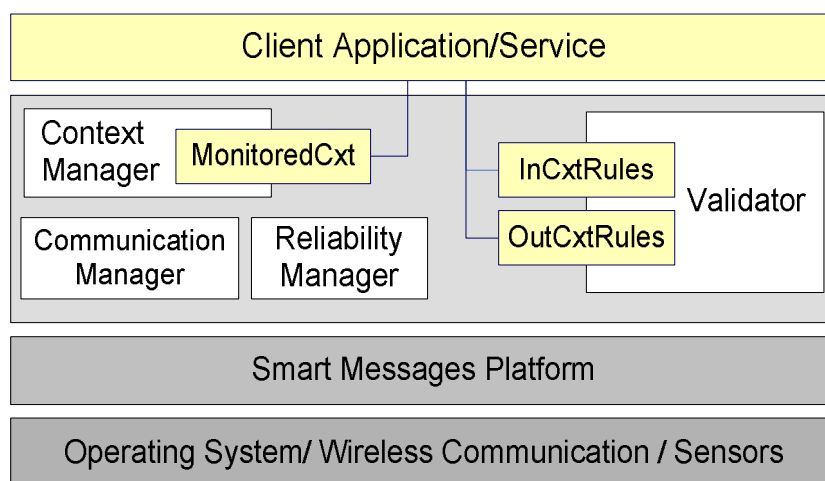
Key ideas in Migratory Services

- Capable of migrating to different nodes in the network in order to effectively accomplish their function
- 3 basic mechanisms:
 - Monitor the **context** of interacting entities
 - Specify in **context rules** how the service execution is context-dependent
 - **Migrate** the service from node to node and resume its execution once migrated
- Service migration is triggered by context changes
- Service migration is transparent to the client

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Migratory Services Framework



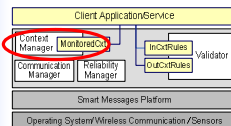
Migratory Service Implementation using Smart Messages

ü Smart Messages

- implemented on a modified version of Sun's Java K Virtual Machine

ü Migratory Services

- clients, migratory services, and meta-services are Java programs that register with the framework
- the framework maps these programs onto lower-level SMs
- SM self-routes using geographical and content-based routing



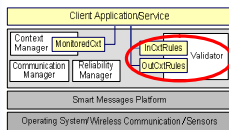
Context Manager

ü Context data provided by the SM platform

- location, time, speed using GPS
- device status information
- neighbors list

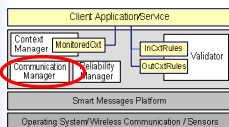
ü *MonitoredCxt* identifiers are translated into SM I/O tags

ü Access to context data by polling or blocking on corresponding SM tags



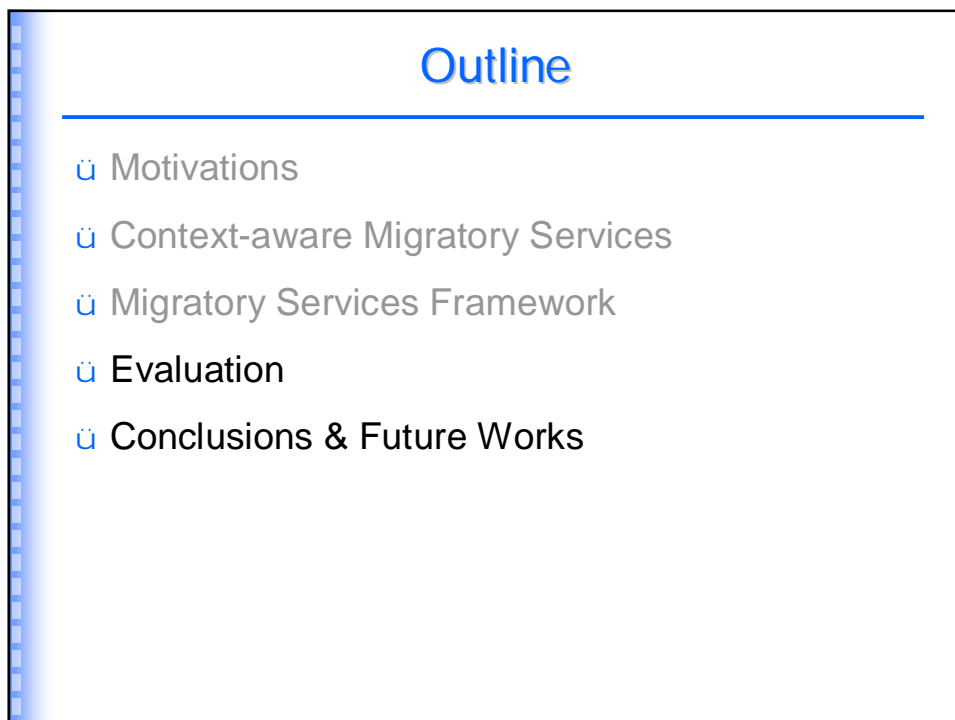
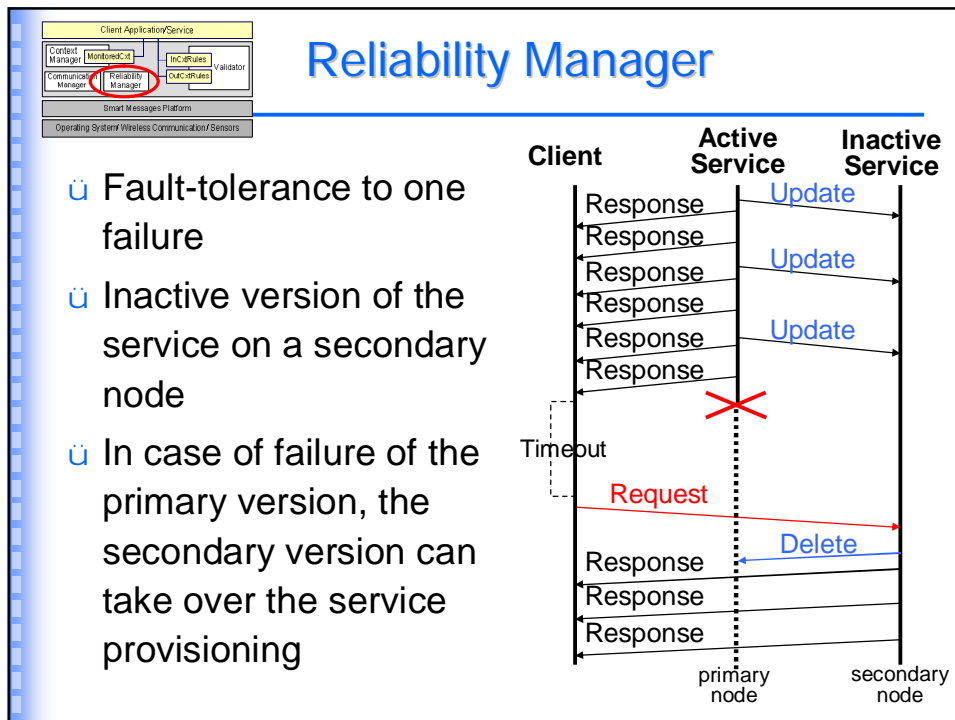
Context Rules and Validator

- ü Evaluate if a service computation can be “correctly” carried out on the current hosting node
- ü If not, trigger migration
- ü CxtRules are service/client-specific policies
 - *inCxtRules* – control on incoming data
 - *outCxtRules* – control on outgoing data
- ü CtxRules are condition/action statements
 - Conditions are full binary trees of Boolean expressions (comparisonNodes + combinationNodes)
 - *Ex: < OR, <batteryLevel, EQUAL, low>, <responseLocation, OUT_REGION, userRegion> >*
 - Actions: *migrate service, send update, accept/refuse response,...*



Communication Manager

- ü Tasks:
 - Discover meta-services
 - Route messages between communicating end-points
 - Carry out service migration
- ü Use naming conventions defined by SM
- ü Two basic SM routing algorithms:
 - geographical routing (similar to GPSR)
 - region-bound content-based routing (similar to AODV)



Prototype Migratory Service: TJam

- ü Predict traffic jams in real-time
- ü Traffic jams are locally congested phases in which cars travel at slow or zero velocity
- ü TJam utilizes two types of information that every car owns:
 - number of one-hop neighboring cars
 - speed of one-hop neighboring cars



$$P_{number} = \max P_{number} \times \frac{avg_{num} - min_{num}}{max_{num} - min_{num}}$$

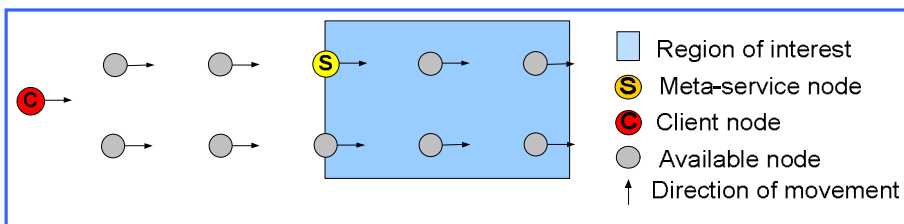
$$P_{speed} = \max P_{speed} \times \frac{avg_{speed} - max_{speed}}{min_{speed} - max_{speed}}$$

$$P'_{ijam} = \alpha \times P_{number} + (1 - \alpha) \times P_{speed}$$

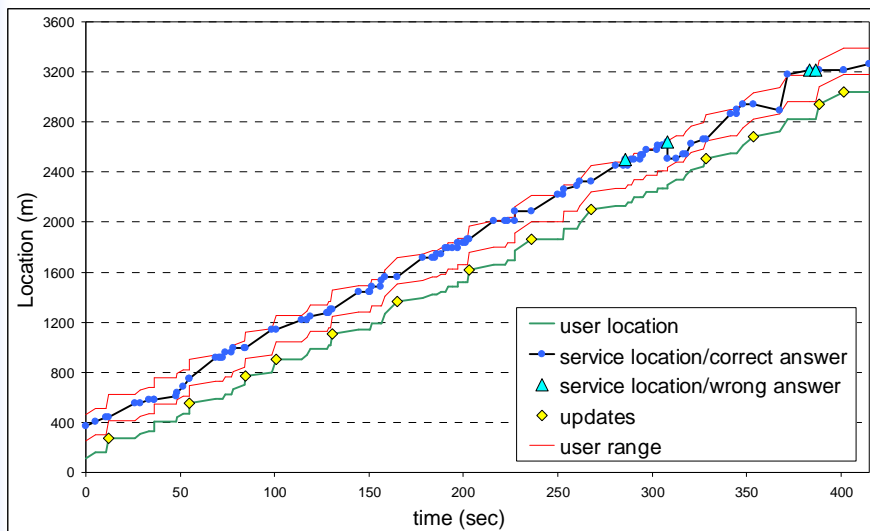
$$P_{ijam} = P'_{ijam} \times \frac{N_{jam}}{N_{total}}$$

TJam: Testbed Experiments

- ü Ad hoc mobile network of 11 HP iPAQs with 802.11 cards and GPS
- ü Use mobility traces
- ü 1-2 hops communication
- ü 2/3 neighbors



TJam constantly executes in the user-specified region

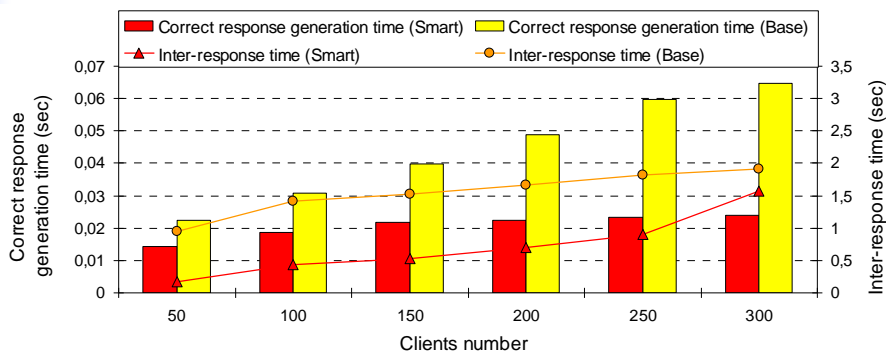


TJam: Simulations

- ns-2 simulator with the CMU-wireless extensions
- microscopic traffic generator tool Micro-VTG
- Goal: Investigate the scalability of migratory services in large scale networks
- Study based on the comparison of
 - *TJam-Smart*: migratory service model implementation
 - *TJam-Base*: baseline centralized approach
- Metrics
 - inter-response time
 - correct response generation time
 - packet utilization rate
 - response packets overhead

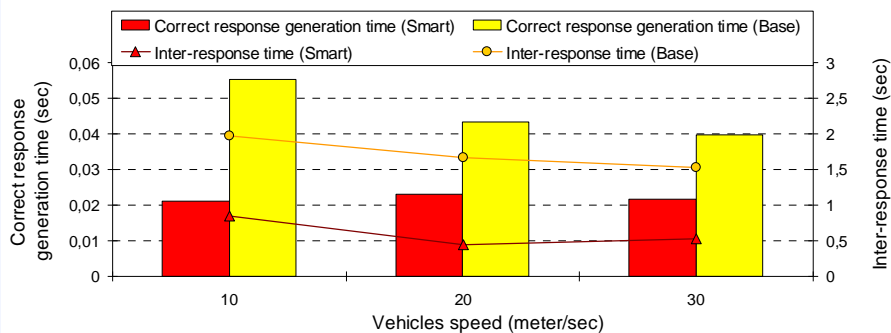
Simulations: effects of number of clients

- highway of length 25km with 3 lanes
- vehicles avg speed is 30m/s with a gap of 150m
- 800 vehicles (500 vehicles active and 50 service nodes)



Simulations: effects of vehicles speed

- 150 clients



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Conclusions

- ü Migratory Services enables a new class of services in ad hoc networks
 - services quickly adapt to changes in the physical environment, in the node capabilities, and network topology
 - service continuity to the client
- ü Experimental results demonstrate the feasibility of our approach
- ü Simulation results demonstrate the scalability and efficiency of migratory services compared to a traditional centralized approach

Future Works

- ü Extend migratory services to smart phones using Portable Smart Messages (J2ME CDC)
- ü Experimental testbed of nokia 9500
- ü Use migratory services to collect context information of entities and environments
 - Integration with the Contory middleware
 - Contory is a middleware for the provisioning of context information on smart phones

Thank you!

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