Z25 Adaptive and Mobile Systems
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MobiPads: A Reflective Middleware for Context-
Aware Mobile Computing

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Motivation of this paper

- Mobile devices have limited resources
  - Bandwidth, memory, CPU, display, **battery**
- Mobile devices are exposed to variation of *context*
  - Bandwidth, connectivity, neighbors, resources
- In particular disconnection happens frequently

- However:

Motivation of this paper (2)

- Middleware for traditional systems is monolithic
- It works based on the black box approach
  - Hides details from applications

- Mobile applications need to be context aware and adaptive to changing context!
- Example: adapt to stream video in black and white (from colour) if the bandwidth drops

Transparency vs Awareness

- Application transparent approach
  - Middleware provides best effort adaptation to context changes (context hidden)
- Sometimes however the application is in the best position to make decisions on operating conditions and adaptation strategy
  - This is often the case in mobile computing, so awareness is good

Content of the Paper

- MobiPADS is a middleware which supports active deployment of context aware services for mobile computing
  - Assume a cellular network with a backbone and some wireless linked nodes which are mobile
- Services (mobilets) are composed to offer augmented services to applications
- MobiPADS uses REFLECTION to achieve adaptation

Reflective Middleware

- Reflection is the ability to monitor and change its computation and its semantics
- Reflective Middleware is able to model itself and auto manipulate its behaviour through *introspection and interception*
- *Introspection* is the ability to observe its own state
- *Interception* is the ability to modify it

Middleware Adaptation

- Interservice adaptation (middleware level)
  - Changes in context trigger service composition at middleware level
  - Eg: drop of bandwidth and increased error rate -> adaptation example: content transcoding of images from colour to grayscale and addition of a local service to perform local error control over wireless link

Middleware Adaptation (2)

- Intraservice adaptation (middleware level)
  - Service objects can react to context events (they subscribe and are notified about the event)
  - Service object can be programmed to behave different after receiving an event notification
  - Eg, a transcoding service object can be programmed to receive event on bandwidth. When bandwidth change, behaviour changes: high-> full colour, medium-> low colour, low-> gray scale

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Middleware Adaptation (3)

- Application adaptation (application level)
  - Application can react to changes in context
  - It subscribes and is notified about context events
  - Application can choose how to change its logic in order to adapt
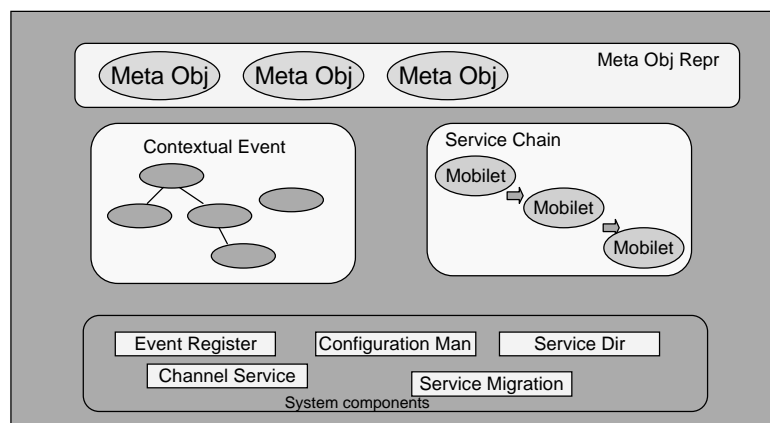 - Eg, video streaming application can reduce frame trasmission rate when bandwidth drops

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System Overview

- MobiPADS server: located on the backbone
- MobiPADS client: located on the mobile device
- One server can support many clients
- Clients provide the services to applications for adaptation

Client/Server Interaction
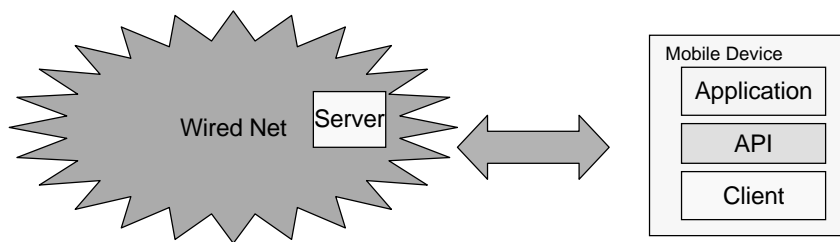
System Framework (Server and Client)

The framework

- System components provide services:
  - Deployment, reconfiguration, management of services
- Service chain: mobilets are composed to offer aggregated services. Mobilets are pairs: one on server and one on client. They cooperate to provide a service.
- Composite events are used to monitor context
- Metaobjects reflect the configuration of the composite events and service chain and adaptation policies
- Middleware and application can inspect and reconfigure events and service chain

Events

- Mobilets and applications can register for events and be notified when something happens
- Possible Events:
  - CPU load level
  - RAM free space
  - Storage free space
  - Battery level
  - Client count
  - Network delay
  - Network error rate
  - Network disconnect
  - Network handoff

System Profiling

- Regulate adaptation through XML profiles
- Event

  HighCPUAvailable= (CPUclockrate=400 and CPUloading <50%) or (CPUclockrate=200 and CPUloading <10%) and Powerwarning=false

- Events can be composed

Reconfiguration

- When change happens (event is triggered):

- Adapt the service chain (the middleware)
- Communicate the change to the mobilets which react internally
- Communicate to application which reacts

Reconfiguration (2)

Reconfiguration entity -> Adaptation Initiator ∨	Mobile Application	Service Chain	Mobilet
Mobile Application	Adjust its behaviour	Using profiles applications can specify service configurations in different contexts	Supplying parameters to mobilets
MobiPad System	Cannot reconfigure application	System profiles can be used to adjust the chain depending on context	System profiles can be used to specify behaviours of mobilets
Mobilet	Cannot affect application	Mobilets cannot affect the whole chain	Reaction of events

Reflection

- Three Metaobjects
  - Context: examination and modification of context info (permits subscription to events)
  - Configuration: shows configuration of service chain (allows adding and removing of mobilets)
  - Adaptation: shows adaptation policies

Examples

- System profile:
  - When bandwidth is low but battery is OK use a service chain with image transcoding and compression services
  - If an event of network disconnection is experienced the application will insert asynchronous data service in the service chain (to keep executing).

Evaluation

- Measured the overhead of reconfiguration
  - Reconfiguration time under different bandwidth for different mobilet sizes with and without active deployment of new mobilets
  - Overhead when active deployment is on is quite high!

Related Work

- Open ORB/COM (Lancaster)
- **CARISMA/SATIN/Runes (UCL)**
- Coda/Odyssey/AURA (CMU)
- GAIA (Illinois)