Predicting Quality-of-Service
for
Nomadic Applications
Using
Intelligent Agents

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Monads Research Project

- Areas of interest
  - usefulness of agents in mobile computing?
  - agent communication in wireless environments
  - adaptability to available resources
  - short-term predictions of available resources
- Experimental software
  - first prototype ready

NOKIA Connecting People sonera TEKES

The Wireless Environment

- The characteristics of wireless networks:
  - long latencies
  - highly variable delays
  - sudden disconnections
- Creates problems that are not met in the wireline networks
- Applications must be able to adapt to sudden changes in the quality of data transmission over wireless connections

Minimal Adaptation

- Detect changes in the Quality-of-Service
- Adapt to the current QoS
  - Abort data transmission tasks that may no longer be completed in a reasonable time
  - Refuse to accept hopeless requests
  - Use special data filtering and compression methods to minimize the amount of data
- Example: a Web browser that shrinks large images when inadequate QoS

Reacting is Not Enough

- Adaptation based solely on reacting to changes in QoS may come too late
- Example: connectivity was lost
  - nothing can be done afterwards
  - something could have been done *beforehand*

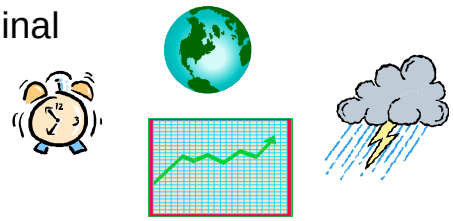
- Too slow reactions may result in 'adaptation' making the situation worse!

Predicting QoS

- Capability of predicting changes in the QoS is required for intelligent adaptation
- Uses for QoS predictions:
  - scheduling decisions
  - data prefetching
  - connection management
- "How much data can we transfer within the next *x* seconds with *p%* certainty?"

Learning to Predict QoS

- Predictions can be achieved by learning how certain quantities affect the QoS
  - location of the terminal
  - time of day
  - day of week
  - recent QoS values

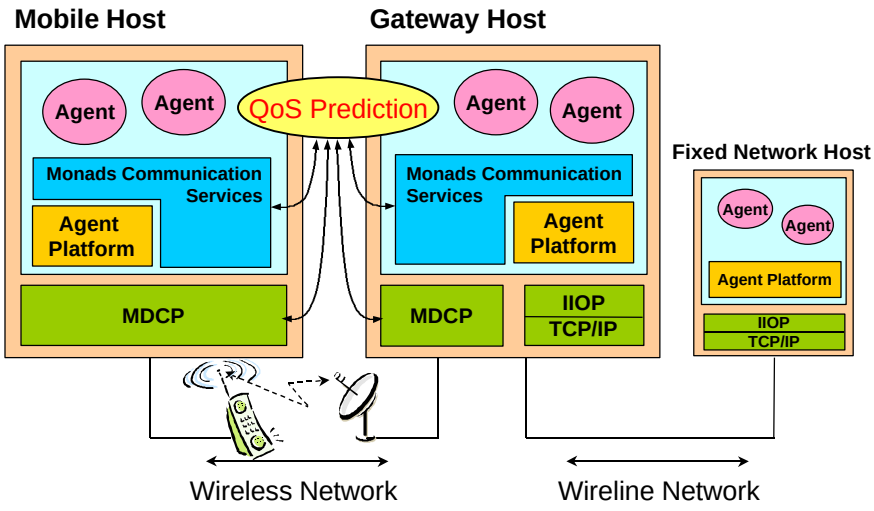


- Division into sub-problems:
  - predicting terminal movement
  - predicting QoS at given location and time

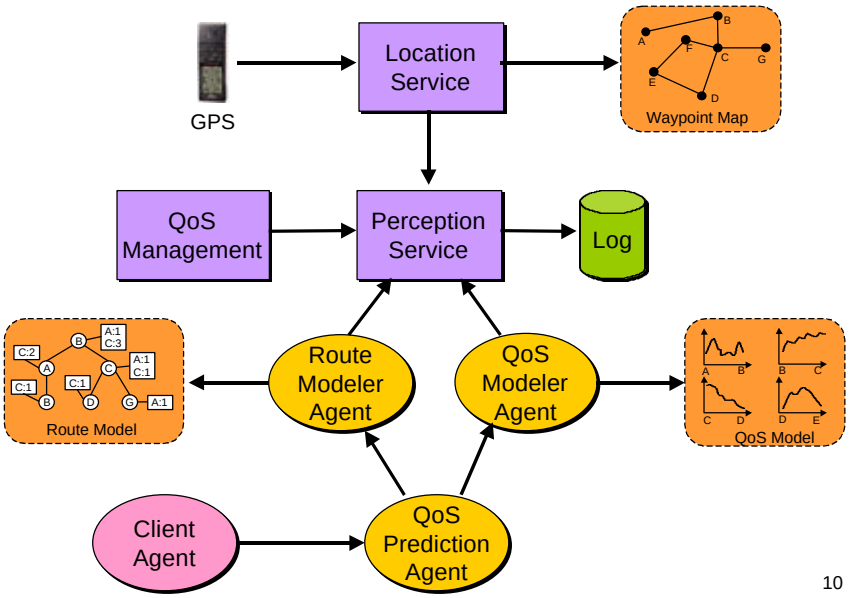
Monads System Architecture

- Built upon existing software systems
  - Mowgli, provides efficient protocols and methods for wireless communication
  - Jade, a FIPA compatible agent platform
    - Agents are implemented in Java
- Simplifies making adaptive applications
  - low-level communication optimized for wireless
  - information about the current and future QoS
  - support for learning and knowledge sharing

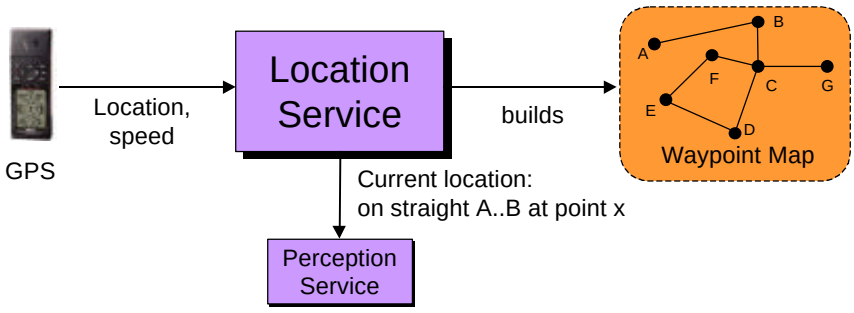
Overall Architecture



Monads System Components

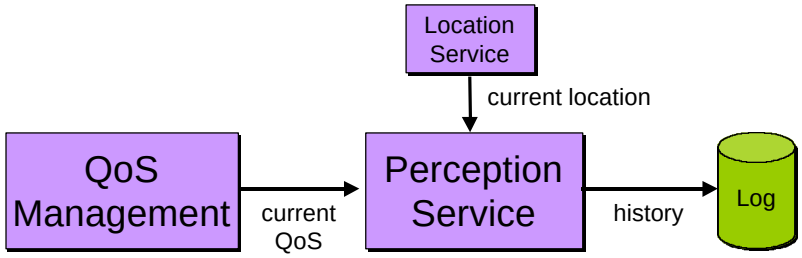


Location Service



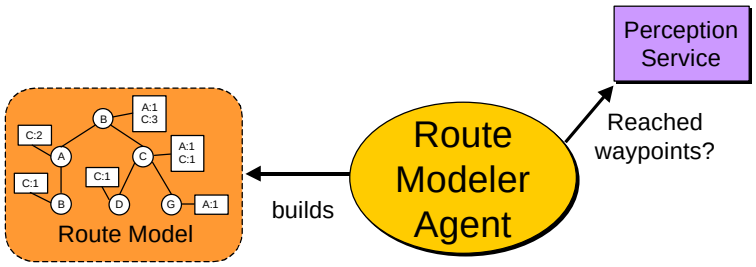
- Reads location information from a GPS device
- Builds a *Waypoint Map*
- Represents the current location as a point on a straight between two waypoints

QoS Management & Perception Service



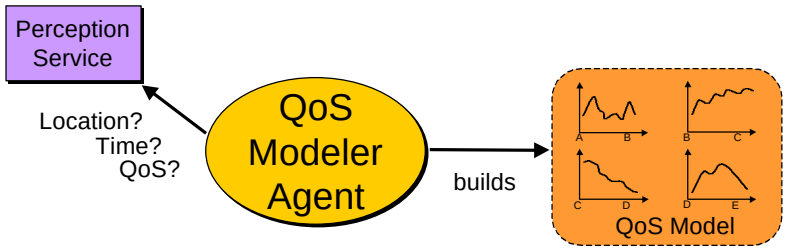
- QoS Management:
  - Provides information about the current QoS
- Perception Service:
  - Centralized collection of observable values

Route Modeler Agent



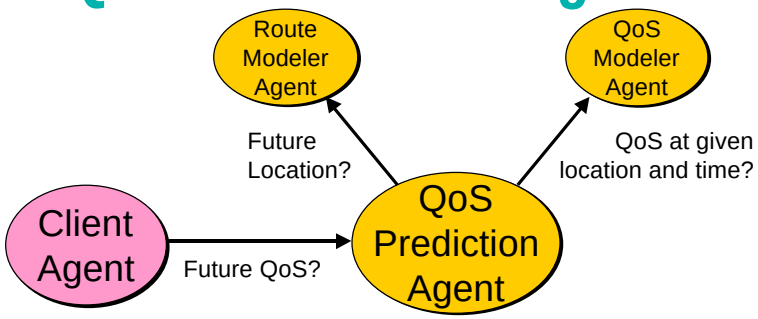
- Actively learns the regular routes of a user
- Provides predictions about user movement
  - given a sequence of waypoints, which will be the following waypoints?

QoS Modeler Agent



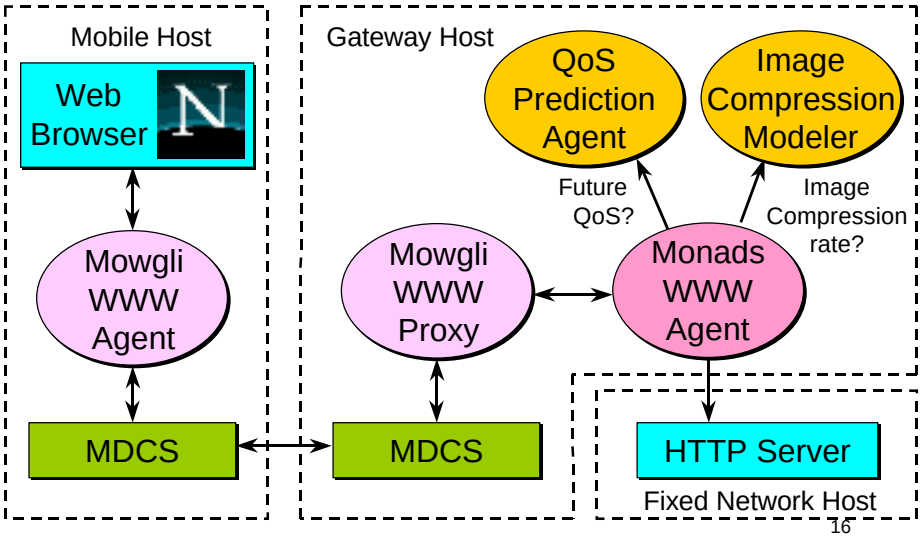
- Actively learns the characteristics of the QoS on the routes traveled
- Provides predictions about the QoS at given location and time

QoS Prediction Agent



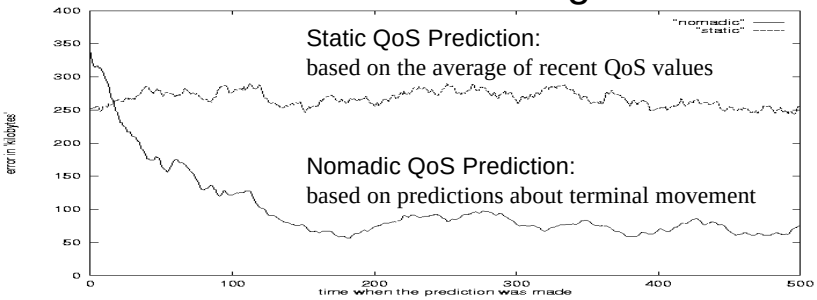
- An intelligent agent that provides QoS predictions
  - combines predictions made by the modeler agents
- Selects between alternative ways to predict
- Informs other agents when the QoS is about to change significantly

Example:
Adaptive WWW Agent



Simulation Results

- The prototype was tested using simulated routes and QoS-map
- Average error of prediction “how much data can be transferred in given time”:



Conclusions

- Nomadic applications must be adaptive
  - Reacting to changes in the QoS is not enough
  - Predicting the changes is the key to intelligent adaptation
- Predictions can be achieved by learning terminal movement and QoS at given location and time
- Next phase is to share learned models between agents in different terminals