Middleware for Nomadic Computing

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Presentation Outline

- Nomadic Computing issues
  - Communication Issues
  - Mobility Issues
  - Device Issues
  - Security Issues
- Middleware for Distributed Computing
  - WAP
  - Java RMI
  - Corba

Presentation Outline

- Enhancing the Middleware
  - Dolmen
  - Nomadic RMI
  - Wireless CORBA
- Conclusions

Nomadic Computing

What's it?

Nomadic Computing

"The essence of a nomadic environment is to *automatically* ***adjust all aspects of user's computing, communications, and storage functionality in a*** *transparent* ***and*** *integrated* ***fashion"*** **– L. Kleinrock, 1997**

Anytime, Anywhere

- A user wants to:
  - use her laptop during a flight and upload her work once disembarked
  - follow financial information independently from the location and time
  - instantiate a communication during a disaster recovery mission
  - access the Internet or Intranet services while on the move.

The Challenges in Mobile Computing

Communication Issues

- Low Bandwidth
  - sending long files requires long time: the chance of experiencing network failures is high
  - a graphical user interface can act in a bizarre way
- High bandwidth variability
  - Bandwidth can increase/decrease four orders of magnitude depending on local conditions (connected/wireless). Ex: videoconference
- Disconnection
  - File system can lock up for a remote server to allow access
  - After reconnections conflicts are possible

Mobility Issues

- Address Migration
  - Physical location != network address
  - To communicate with a mobile computer is necessary to know its most recent address
- Location-dependent information
  - Some information depend on location, as local printers or local currency.
  - In a mobile environment these information cannot be stored statically and they must be found dynamically

Devices Issues

- Power limitation
  - Energy supply is a bottleneck for mobile devices
  - Bigger batteries => more weight
  - The user wants long-lasting AND light devices
- User Interface and Display Issues
  - Size constrains force to use small user interface
  - Small display size makes access to remote service difficult
  - Input devices must be redesign (keyboard -> pen-based recognition)
  - Hand-writing and sound recognition

Security Issues

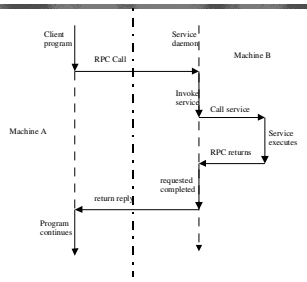
- Identification
- Certification
- Privacy
- Insecure channels
- Insecure devices (can be stolen)
- ...

Middleware for Distributed Computing

Middleware for Distributed Computing

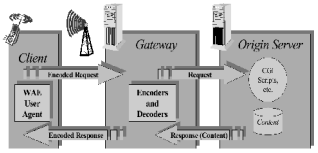
- Remote Procedure Call (RPC)
  - 1976. Provides communication across a network between programs written in a *high-level* language
  - Using procedure calls mechanism is easier than building a communication paradigm
  - It presumes the existence of TCP/IP or UDP
  - Its use is in decline: not implemented in object oriented programming languages
- Java RMI
  - 1998. Same concept implemented in Java.
  - More later…

Remote Procedure Call (RPC)

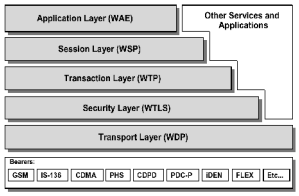


Middleware for Distributed Computing

- Wireless Application Protocol
  - Designed for Nomadic devices
  - It provides Internet access for phones and small PDAs



WAP - Architecture



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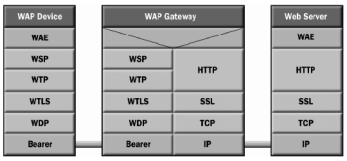
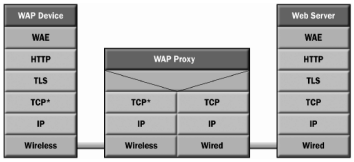


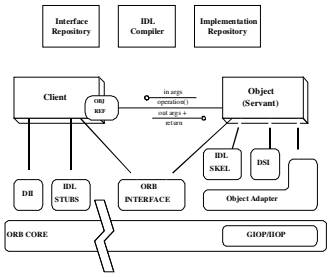
WAP – Architecture 2.0



Middleware for Distributed Computing

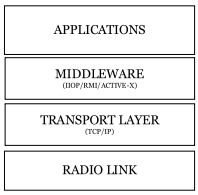
- OMG CORBA
  - 1989. Provides interoperability between *objects* in a *heterogeneous*, distributed environment
  - Interfaces specified in OMG IDL
  - Not suited for wireless networks, since it requires reliable communication
  - Not suited for mobile device, since the terminal cannot change its point-of-presence
- Microsoft COM and DCOM
  - COM allows *binary* interoperability between distributed objetcs
  - NOT platform independent and proprietary protocols

OMG CORBA – Architecture



Enhancing the Nomadic Layers

Nomadic Computing - Layered



Improving *Long Thin Networks*

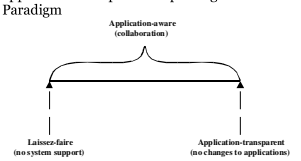
- Slow Start and Congesting Avoidance
  - the system assumes the network is congested while packets are dropped for corruption
- Delayed ACKs
  - the dimension of the sender's window depends on the number of ACKs it receives. Adaptation is slow
- Three-way Handshake
  - data transfer is possible only after the handshake is completed. Long latency makes short transactions unattractive
- Lenght of TCP/IP headers

Improving TCP over Wireless

- Solutions:
  - modify or eliminate slow start
  - Use larger initial windows
  - Count the data acknowlegde not the number of ACK
  - Change the spacingbetween ACKs
  - Compress headers or compress IP payload
  - SNOOP (Berkeley)
    - Split connection approach, but maintaining end-to-end semantic
    - retransmission of lost packets only locally
    - suppression of duplicate ACKs from receiver to sender

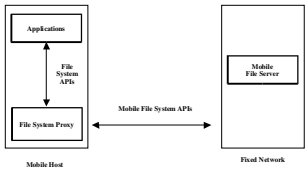
Improving Client-Server Paradigm

- Satyanarayanan [1996]:
  - Extremes of adaptation: *laissez-fair* and application-transparent Improving Client-Server Paradigm

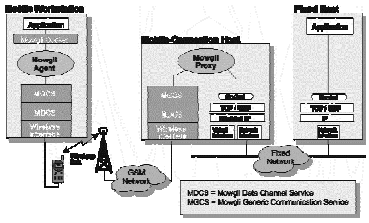


Enhancing the Communication Layer

- Example: Coda File System

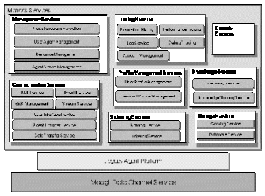


Mowgli Project



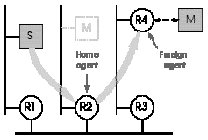
Monads

- Adaptation agents for Nomadic Application.
- The key work is ”prediction” through learning



Addressing the Mobility Issues

- Mobile IP



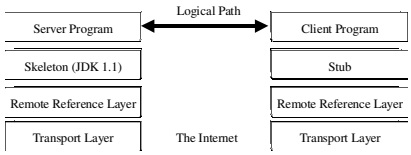
Enhancing The Middleware Layer

Nomadic RMI

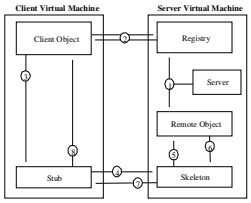
Remote Method Invocation

- RMI protocol interface lets Java objects on different hosts communicate with each other in a transparent way
- Clients can invoke methods of a remote object as if they were local methods
- Preserve the object oriented paradigm in distributed computing

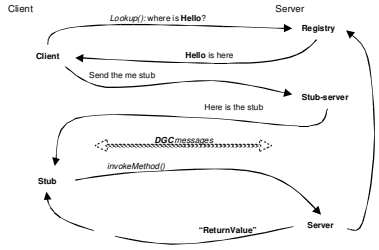
Java RMI - Layers



Java RMI - Protocol



Java RMI in a Nutshell



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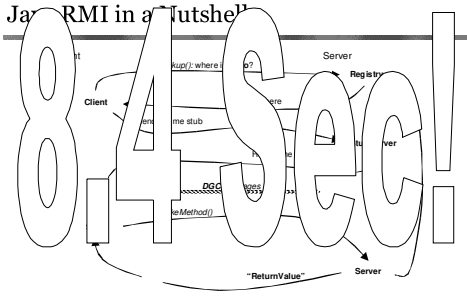
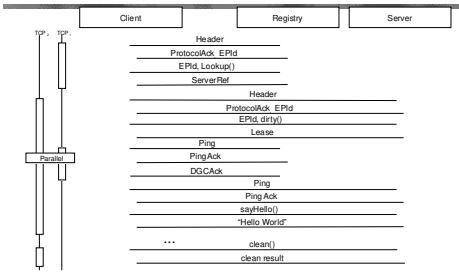


8 A Sec!

"Hello World" Example



Data traffic analysis

	Client to Server and Registry (bytes)	Server and Registry to Client (bytes)	Total (bytes)
Registry Lookup	55 (6%)	276 (42%)	331 (20%)
Invocation Data	41 (4%)	37 (6%)	78 (5%)
DGC Data	831 (85%)	305 (46%)	1136 (69%)
Protocol Overhead	52 (5%)	40 (6%)	92 (6%)
Total	979 (100%)	658 (100%)	1637 (100%)

RMI Optimization

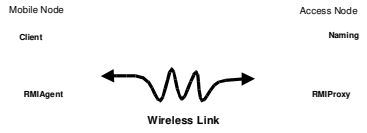
- Maintain compatibility with Java RMI specifications
- Avoid redundancy in communication protocol
- Use compression and caching to minimize data transmission

Java RMI Optimization

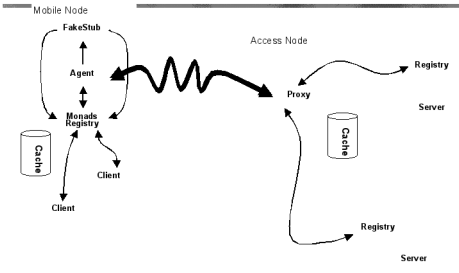
- Protocol
  - Use of Mediators to minimize the exchange of data through the wireless link.
- Data Communication
  - Optimized Communication: Compress and Optimize data communication
- Class Loading
  - If possible, avoid to download stubs

Protocol Optimization

- The idea is to de-couple the connection between the client and the server using mediators.



Optimized RMI



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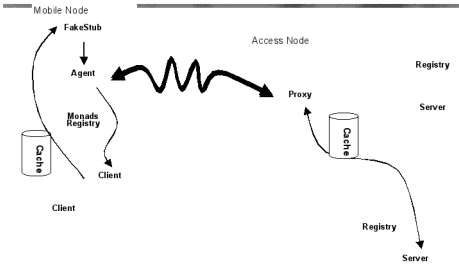
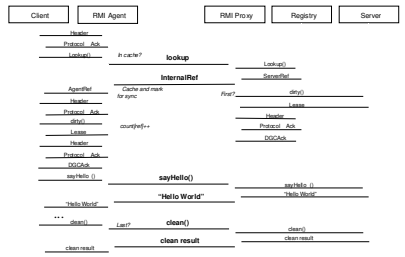


Optimized Remote Invocation



Comparison between RMI and ωRMI

	Registry Invocation	Remote Invocation	Total
Java RMI	7.1 sec	1.3 sec	8.4 sec
Optimized RMI	1.7 sec	0.6 sec	2.3 sec
Improvement	417%	216%	365%

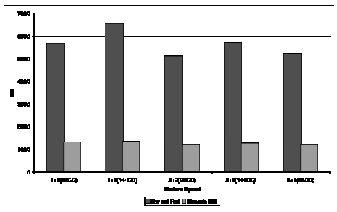
Test Arrangements

- Operating Systems
  - Clients:
    - Windows98
    - Linux (Red Hat 6.1, kernel 2.2.14)
  - Server
    - Windows NT (SP 6)
    - Linux (Red Hat 6.1, kernel 2.2.14)

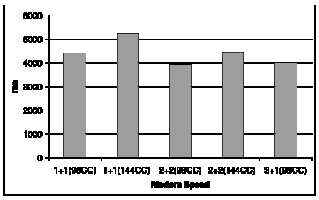
Test Arrangements

- Java Virtual Machine
  - Sun JDK 1.2.2 (Linux and Windows)
- Wireless communication
  - GSM HSCSD (5 configurations)
- Benchmark Suite
  - KaRMI from University of Karlsruhe

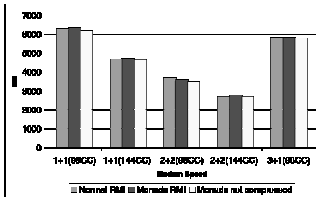
Lookup Results (windows)



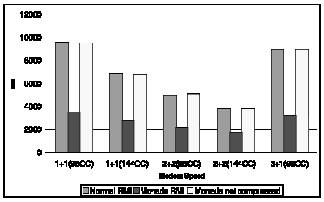
Lookup Differences



Invocation Results
Image Uplink (Linux)



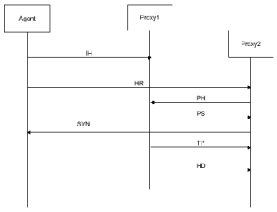
Invocation Results
Two-way Text uplink



Nomadic RMI

- The previous solution does not support mobility
  - If the connection between mobile host and RMI Agent is interrupted the system is in an unstable state
- ηRMI (Nomadic RMI) Protocol addresses this problem
  - It allows Handover between different access points

Nomadic RMI



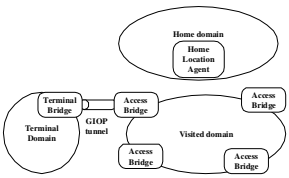
Enhancing The Middleware Layer

Wireless CORBA

Issues of CORBA in Nomadic Environment

- IIOP servers are not expected to change their transport connection endpoint
- IIOP and the transport connections are supposed to be reliable
- It is not possible to change network interface during an IIOP connection
- Connections are expected to enjoy high bandwidth

Wireless CORBA – Architecture



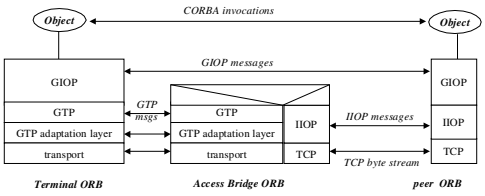
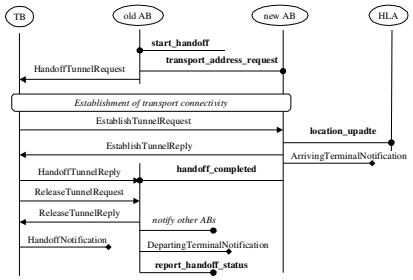
wCORBA Framework

- Mobile IOR
  - Identifies the terminal on which the target object resides
  - And its Access Bridge
- Home Location Agent
  - Keeps track of the current location of the terminal
- Access Bridge
  - End-point of the GIOP tunnel in the network side
- Terminal Bridge
- GIOP tunnel

wCORBA Framework

- Terminal Bridge
  - End-point of the GIOP tunnel on the terminal side
- GIOP tunnel
  - Is the means to transmit GIOP messages between the Terminal Bridge and the Access Bridge

Wireless CORBA - GIOP Tunneling Protocol



Wireless CORBA – Handoff