Software Engineering and Middleware: A Roadmap

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What is Middleware?

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Requirements for Middleware

- Help implementing non-functional requirements ("ilities")
  - Network communication
  - Coordination of distributed components
  - Reliable execution of components
  - Scalability to future loads
  - Securing components against intruders
  - Resolving heterogeneity of
    - hardware
    - operating systems
    - network protocols
    - component implementations
    - middleware

Middleware Solutions

- Transaction-Oriented
  - IBM CICS
  - BEA Tuxedo
  - Encina

- Message-Oriented
  - IBM MQSeries
  - DEC Message Queue
  - NCR TopEnd

- RPC Systems
  - ANSA
  - Sun ONC
  - OSF/DCE

- Object-Oriented
  - OMG/CORBA
  - COM
  - Java/RMI

- Component-Oriented
  - Enterprise Java Beans
  - COM+
  - CORBA Components
Message-Oriented Middleware

Request Queue

Client

Server

enter

remove

enter

remove

Reply Queue

Message-Oriented Middleware

Transaction-Oriented Middleware

Acc1@bankA :Resource

Acc2@bankB :Resource

:Coordinator

begin()

debit()

credit()

commit()

register_resource()

prepare()

prepare()

commit()

commit()
**Procedural Middleware**

- **Caller**
- **Stub**
- **Called**
- **Stub**
- **Transport Layer (e.g. TCP or UDP)**

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**Object-Oriented Middleware**

- **Client**
- **Client Stubs**
- **ORB Interface**
- **Object Implementation**
- **Implementation Skeletons**
- **Object Adapter**
- **ORB Core**
Component-Oriented Middleware

Session Container  Entity Container  Other Container

Home  Home  Home

POA  POA  POA

Transactions  Security  Persistence  Notification

Middleware Research

- Recent trends in ICDCS, Middleware and EDOC Conferences include
  - Component location by trading (Raymond)
  - Reflexive Middleware (Blair)
  - Non-transparent replication (Tanenbaum)
  - Middleware for real-time systems (Schmid)
  - Middleware for mobile and pervasive computing (Sun, Picco)

- Will influence middleware solutions 3-5 years down the road
**Trends**

- Middleware incredibly successful in industry because they provide programming and run-time environment for building reliable, secure, scalable, open and distributed software systems
- Middleware industry has proven track record for efficient transfer of research results into products (e.g. ODP Trading)
- If software engineering research ignores this our results will be ignored!

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**Basic Research Question**

- Middleware provides the programming support, but what about analysis, architecture, design and testing of middleware-based distributed systems?

- How do we build on middleware to systematically engineer software systems?
Requirements Engineering

- Existing requirements engineering techniques have a strong focus on functional requirements
  - Use case based approaches
  - Formal methods
- Middleware selection needs to be driven by non-functional requirements
- How do we specify (and quantify!) non-functional requirements?
- How do we elicit dimensions in which they may change?

Software Architecture

- ADLs will be superseded by the IDLs, CDLs and CIDLs that are provided by middleware
- Middleware provides connectors
- How do we select an appropriate middleware as the basis of a distributed software architecture?
- Difficulties:
  - Complexity of middleware solutions
  - Rapid development of the industry
Software Architecture

- Research challenge: Specify / reason on non-functional characteristics of SW architecture
- Speculative Examples:
  - Performance and Scalability: Queing Theory and Markov Models?
  - Security: Deontic Logic?
  - Coordination: Process algebra?

Design

- Reflection makes various aspects of distribution visible to distributed systems engineers
- We need design notations, methods and tools that can express concerns such as
  - application-level transport protocols
  - replication strategies
  - scheduling policies
  - location-awareness
Conclusions

- Middleware solutions assist in building complex distributed systems right now
- Middleware research results will extend that support in the future
- Potential synergies between software engineering middleware research: SE community needs to build on middleware and support requirements, architecture, design and test stages of the distributed systems life cycle

Further Information

- http://www.distributed-objects.com
- http://www.omg.org
- http://www.msn.com
- http://www.cetus-links.org