Global Scheduling and Binding in a Real-Time Embedded Distributed System

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Presentation Outline

- Dynamic QoS Services
- Dynamic QoS Services Architecture
- Global Scheduling
- Dynamic Binding
- Adaptive Meta-Service
- Application
**Dynamic QoS Services**

- **Global Distributed Services**
  - UAV
  - Combat System

- **High-level distributed middleware scheduling**
- **Low-level middleware /endsystem scheduling**
- **RT OS level scheduling**

- **Work within open systems / COTS**
- **QoS with focus on real-time**
Dynamic QoS Services Architecture

- System Designer
- Offline RT Analysis and Prototyping
- Global Scheduling Service
- Adaptive Meta-Service
- Dynamic Binding Service
- RT QoS Server Object
- RT Operating System
- Real-Time ORB
- Network

Client

RT Operating Systems
Dynamic QoS Services Architecture

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- Client
- RT Operating System

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Global Scheduling Service

priority assignment, overload management, priority mapping, concurrency control

RT QoS Server Object

RT QoS Server Object

RT QoS Server Object

RT Operating Systems
Global Scheduling Service

- Accepts client deadline and importance
- EDF schedulability analysis
- Global Prio assignment and adjustment
- Overload management – load shedding based on importance
- Basic Priority Inheritance based CC
- Sets servant global Priority
Global Scheduling Algorithms

- Overload management
  - Load shedding
    » When requested task cannot be scheduled, scheduling service must “shed” one or more tasks
    » Compute *Shedding Parameter* (SP) based upon:
      - Importance
      - Remaining execution time
    » Shed task with smallest SP
  - Load reduction
    » variation on load shedding
    » reduce execution time and quality of task result instead of shedding
Dynamic QoS Services Architecture

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- Dynamic Binding Service

Offline RT Analysis and Prototyping

System Designer

RT Operating System Real-Time ORB RT Operating Systems

Client

Network

RT QoS Server Object

RT QoS Server Object

RT QoS Server Object

RT Operating Systems
Dynamic Binding Service

Bind a client to best object based on real-time criteria

RT Operating System

Network

Client

Dynamic Binding Service

RT QoS Server Object

RT QoS Server Object

RT QoS Server Object

RT Operating Systems
Dynamic Binding Service

- Servers register service and execution times
- Clients request service with deadline
- Binding Service finds all servers that offer the service
- Eliminates those on which load will not fit
- Chooses among remaining servers based on Slack-Time Driven Load Allocation Heuristic

RT Operating System

RT Operating Systems

RT QoS Server Object

RT QoS Server Object

RT QoS Server Object
Load allocation

- Goal: Choose the node on which new task fits most tightly, but where tight tasks are finishing soon
- Similar to “Best Fit”
- Computer *Allocation Parameter* (AP) for each candidate node based on:
  > minimum slack time of all tasks with shorter deadline than new task
  > deadline of task with minimum slack time
- Choose node with minimum AP
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Network
Adaptive Meta-Service

- *Hierarchy of service configurators*
- *Services specify parameters, policies and algorithms*
- *Meta-service sets parameters, policies and algorithms*
- *Makes trade-off among conflicting policies, etc.*
Adaptive Meta-Service

Sets RT sched policy (e.g. Rate-monotonic or EDF)

Performs Real-Time Scheduling

Sets Security Policy

Sets Policies to Tradeoff Real-Time For Security

Service Extension Interface

Real-Time Meta-Service

Control Service Interface

QoS Meta-Service

Control Service Interface

Service Extension Interface

Sched Service Interface

Service Interface

Service Interface

Binding Service

Client

Client

Client

Client

Client

Client

Service Extension Interface

Security Meta-Service

Control Service Interface

Service Extension Interface

Service Extension Interface

University of Rhode Island

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BBN’s UAV Application

Dynamic binding
- bind viewer to distributor that will provide best service to viewer

Global Scheduling
- required across distributed system
- schedule tasks and streams
- load shedding to avoid overload

Images courtesy of BBN
Future Directions

- End-to-end scheduling
  - Scheduling nested requests
  - Load shedding with dependencies
- Algorithm development
  - Dynamic priority adjustment
  - Dynamic priority mapping
- Meta-service refinement
  - Continue work on architecture
  - Algorithms for QoS trade-off
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