Real-Time Systems
Scheduling Algorithms

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Outline
- Definition of Terms
- Timeline
- Basic Research
- Concept Formation
- Development, Extension, Exploration
- Popularization

Definitions (1)
- Static/offline scheduling – schedule is determined beforehand
- Dynamic/online scheduling – schedule is determined during execution
- Preemptive – execution is suspended if a higher priority task arrives
- Non-preemptive – task is allowed to finish execution without interruptions

Definitions (2)
- Static priority – task priority does not change during execution
- Dynamic priority – task priority can change during execution
- Periodic – time-driven; occurs at fixed time intervals
- Aperiodic – event-driven; unpredictable
Timeline

1970
- Bus scheduling
  - Stability algorithm (Gantt charts)

1980
- Scheduling theory
  - Preemptive scheduling
    - RMS, EDF
  - Best fit

1990
- Distributed scheduling
  - Distributed nodes
  - Nonsymmetric scheduling
    - Resource Reclaim, CTI
  - RT Round Robin

2000
- Distributed scheduling
  - Distributed nodes
  - Nonsymmetric scheduling
    - Resource Reclaim, CTI
  - RT Round Robin

Basic Research

1960's
- Scheduling done by hand
- Best fit
- Use Gantt charts
- Stability algorithm (Gantt charts)

1970
- Concept Formation
  - Basic Research

1980
- Preemptive scheduling
  - RMS, EDF
  - Scheduling theory

1990
- Multiprocessors
  - Periodic & Aperiodic
  - Distributed nodes

2000
- Preemptive scheduling
  - RMS, EDF
  - Scheduling theory
Concept Formation

- Late 1960’s – Early 1970’s
  - Scheduling theory
  - Preemptive scheduling for multiprocessors
  - Rate Monotonic Scheduling (RMS)
  - Earliest Deadline First (EDF)

Multiprocessors

- Multiprocessors
  - Basic Research
  - Concept Formation
  - Distributed nodes
  - Periodic & Aperiodic
  - 1970
  - 1980
  - 1990
  - 2000
  - Tasks with release times, due times, deadlines
  - Non-uniform processors
  - Any number of processors

Multiprocessor what ifs…

- Late 1970’s – Early 1980’s
  - More than 2 processors
  - Uniform processors
  - Non-uniform processors
  - Tasks with release times, due times, and deadlines

Distributed Nodes

- Basic Research
  - Concept Formation
  - Distributed nodes
  - Multiprocessors
  - Periodic & Aperiodic
  - 1970
  - 1980
  - 1990
  - 2000
  - Distributed scheduling
  - RT Round Robin
  - Mixed TT/ET
  - Poplarization
What if nodes are distributed?

- Mid 1980’s – present
  - Bus scheduling
  - Distributed scheduling
  - Nonsymmetric scheduling
  - Real-time round robin
  - Mixed time- and event-triggered tasks

Mixed Time/Event-Triggered Systems

- Question: Development Method
- Result: Technique
- Validation: Example
- Holistic scheduling and schedulability analysis for mixed tasks (TT/ET) and mixed messages (static/dynamic)

Periodic & Aperiodic Tasks

- 1970
  - Basic Research
- 1980
  - PE, DS, EPE
- 1990
  - Resource Reclaim, CTI
- 2000
  - EDV, VED

- Concept Formation
- Multiprocessors
- Distributed nodes
- Periodic & Aperiodic

What if not all tasks are periodic?

- Late 1980’s – present
  - Priority Exchange (PE), Extended PE (EPE)
  - Deferrable Server (DS)
  - Immediate Server (IS)
  - Slack stealing algorithm
  - Resource reclaiming algorithms
  - Critical Task Indicating (CTI)
  - EDV, VED
Popularization

- 1970
- Basic Research
- Concept Formation
- Multiprocessors

- 1980
- Distributed nodes
- Periodic & Aperiodic

- 1990
- Safety-critical (avionics)
- Futurebus+, Ada, CAN

- 2000
- FlexRay
- CORBA

1990’s – present
- Safety critical systems (Avionics, Cars)
- Futurebus+
- Ada
- Controller Area Network (CAN)
- Time-Triggered Protocol (TTP)
- FlexRay
- Real-time CORBA
- Real-time Java

Predictable Avionics Platform in Ada

- Question: Feasibility
- Result: Report
- Validation: Example
- RMS was used in the General Avionics Platform application

Bibliography (1)

Bibliography (2)


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Bibliography (3)


Bibliography (4)


Algorithms (1)

- Rate Monotonic Scheduling (RMS) – task with shortest period has highest priority
- Earliest Deadline First (EDF) – task with earliest deadline has highest priority
- Priority Exchange (PE) – aperiodic task slot is swapped with periodic task slot
- Deferrable Server (DS) – aperiodic task slot is kept until time expires
- Extended Priority Exchange (EPE) – uses unused time of periodic tasks to service aperiodic tasks
### Algorithms (2)
- Noncooperative (NC) – task is rejected if it can’t be scheduled locally
- Random Scheduling (RS) – task is sent to a randomly selected node
- Focused Addressing (FA) – task is sent to a node that is estimated to have enough surplus
- Bidding – task is sent to a node based on best bid received from nodes in the system
-Flexible – task is sent to a node based on a combination of focused addressing and bidding

### Algorithms (3)
- Immediate Server (IS) – similar to PE but aperiodic server has highest priority
- Critical Task Indicating (CTI) – tasks are deferred until their critical deadline point
- Earliest Deadline first with larger Value (EDV) – tasks with same deadline but higher importance have higher priority
- Value first with Earliest Deadline (VED) – tasks with same importance but earlier deadline have higher priority