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Promote-IT: An Efficient Real-Time Tertiary-Storage Scheduler

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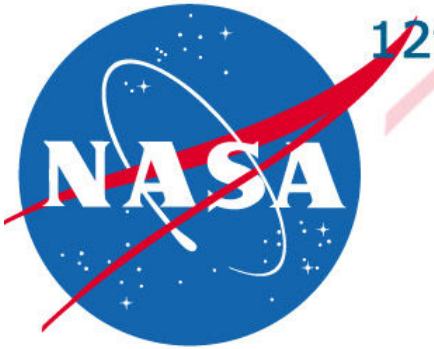

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The Inn and Conference Center
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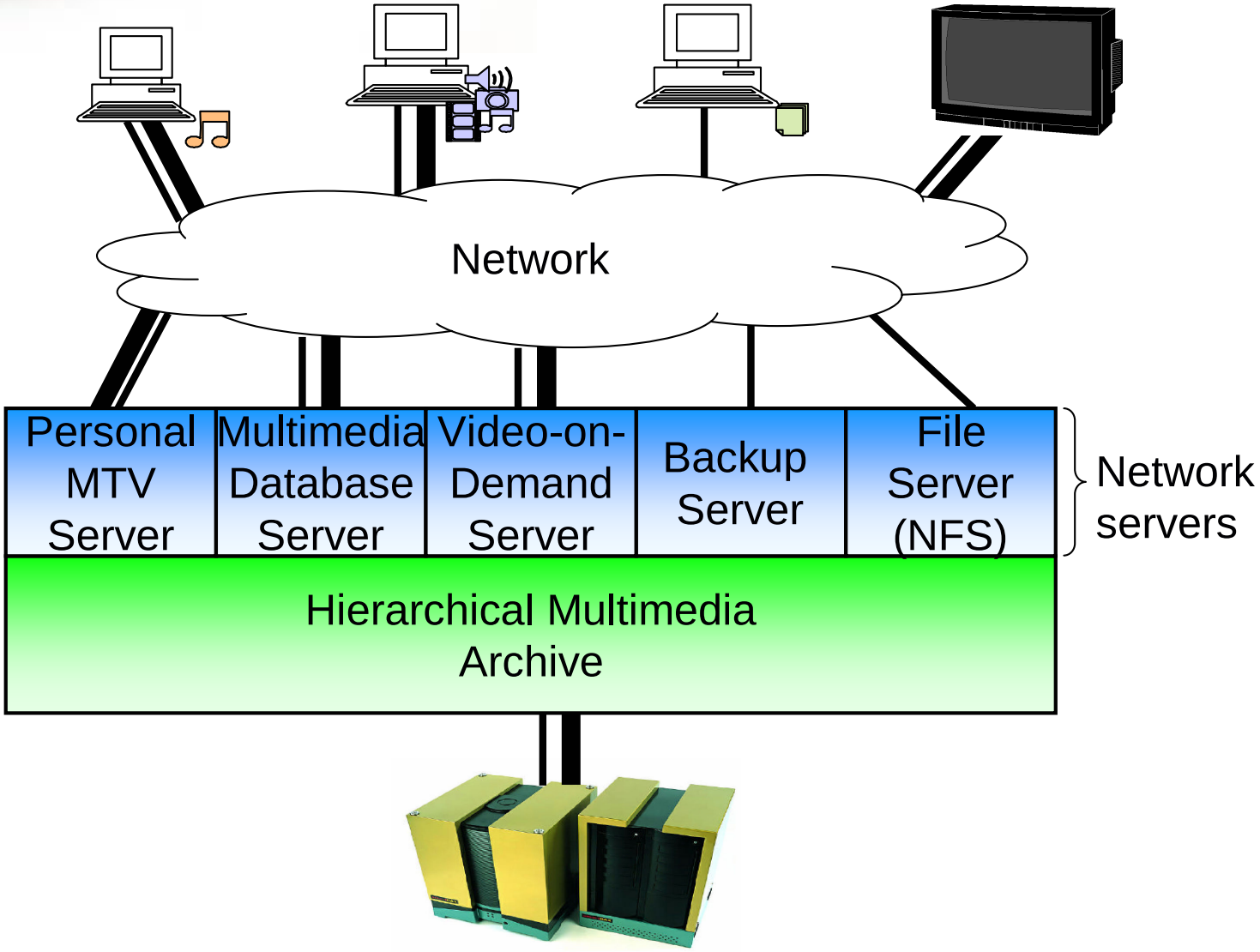
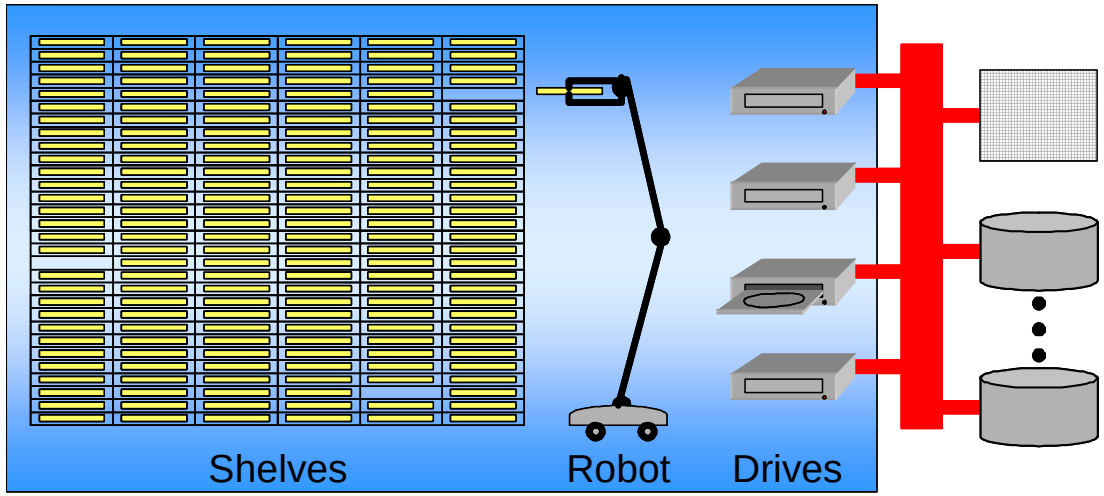
Structure of the Talk

- Hierarchical Multimedia Archive
- Jukebox Scheduler (Promote-IT)
- Performance Evaluation
- Conclusions

System Overview



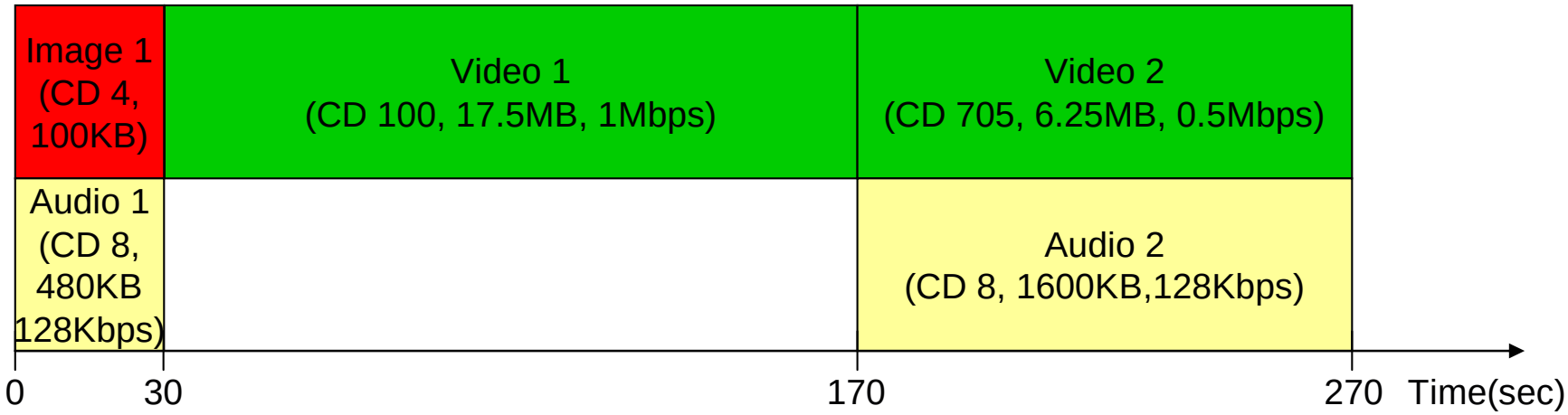
Jukebox Architecture



- Storage capacity
- Cost/GB
- Reliability

- Switching times
- Few drives
- Shared robots
- Potential resource-constraint problems

Request



Request = {deadline, asap, maxConf,{Request Unit}*}

Request Unit = {medium, offset, size,
Δdeadline,bandwidth}

Scheduler Goals

- Guarantee real-time access to data
  - No hiccups or interruptions
  - Data available according to request
  - (Best-effort if access differs from request)
- Minimize response time ASAP requests
- On-line scheduling
- Minimize confirmation time
- Make good use of jukebox resources

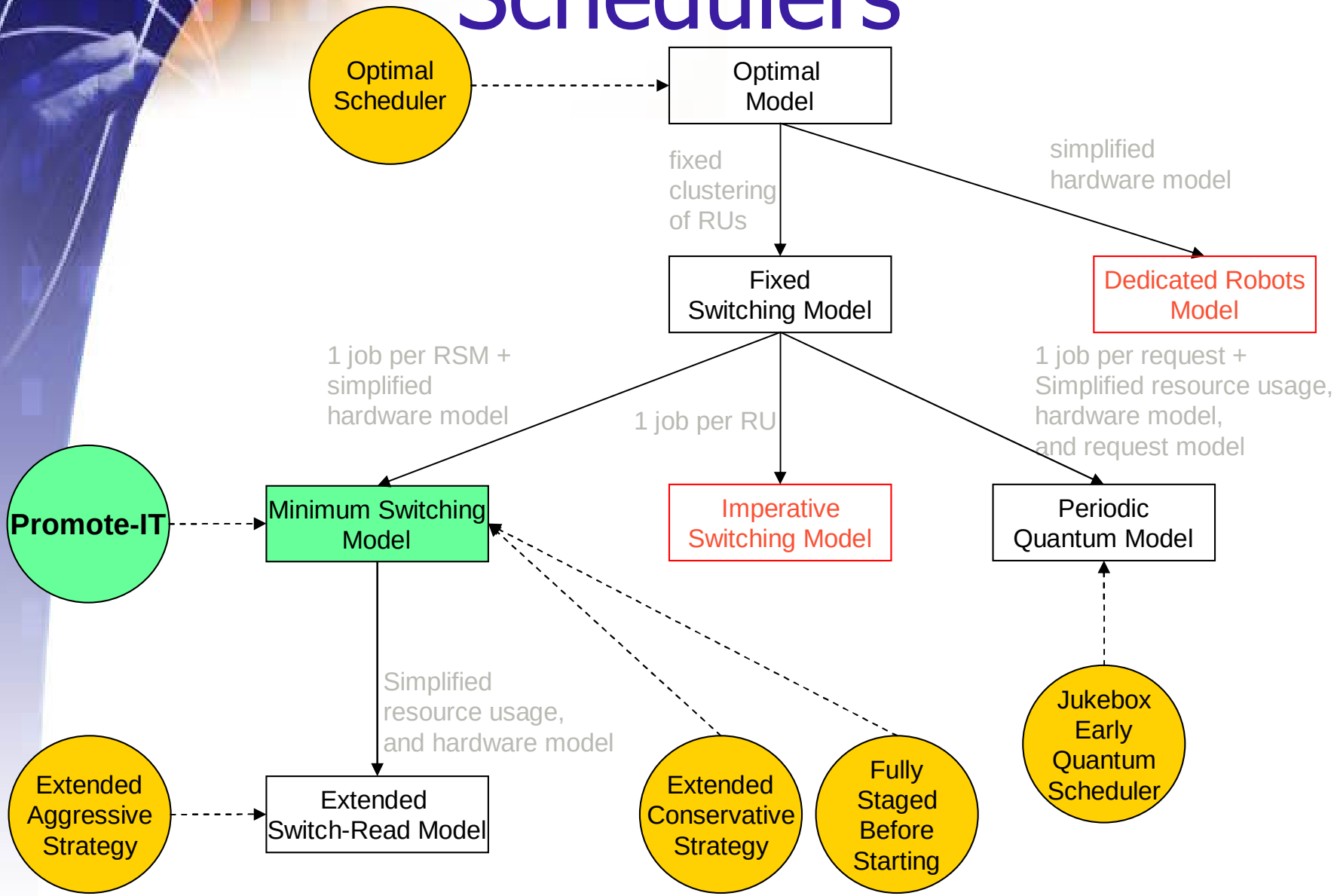
Solution Guidelines

- Secondary storage as buffer and cache
- Detailed and flexible hardware model
- Formal model of scheduling problem
- Separate Schedule Building and Dispatching
  - Early Dispatcher

Hardware Model

- Removable Storage Media (RSM)
  - Any number
  - Different types (optical disks, tape)
  - Different types in jukebox (DVD, CD, DVD-RAM)
- Drives
  - Any number
  - Non-identical
  - Parameters depending on RSM
- Robots
  - Any number
  - Scope: Shared/dedicated/serving a set of drives and RSM
  - Functionality: Loader/Unloader/Loader-Unloader
  - Parameters depending on drives and shelves

Schedulers


Optimal Scheduler
Optimal Model
fixed clustering of RUs
simplified hardware model
Fixed Switching Model
Dedicated Robots Model
1 job per RSM + simplified hardware model
1 job per RU
1 job per request + Simplified resource usage, hardware model, and request model
Promote-IT
Minimum Switching Model
Imperative Switching Model
Periodic Quantum Model
Simplified resource usage, and hardware model
Jukebox Early Quantum Scheduler
Extended Aggressive Strategy
Extended Switch-Read Model
Extended Conservative Strategy
Fully Staged Before Starting

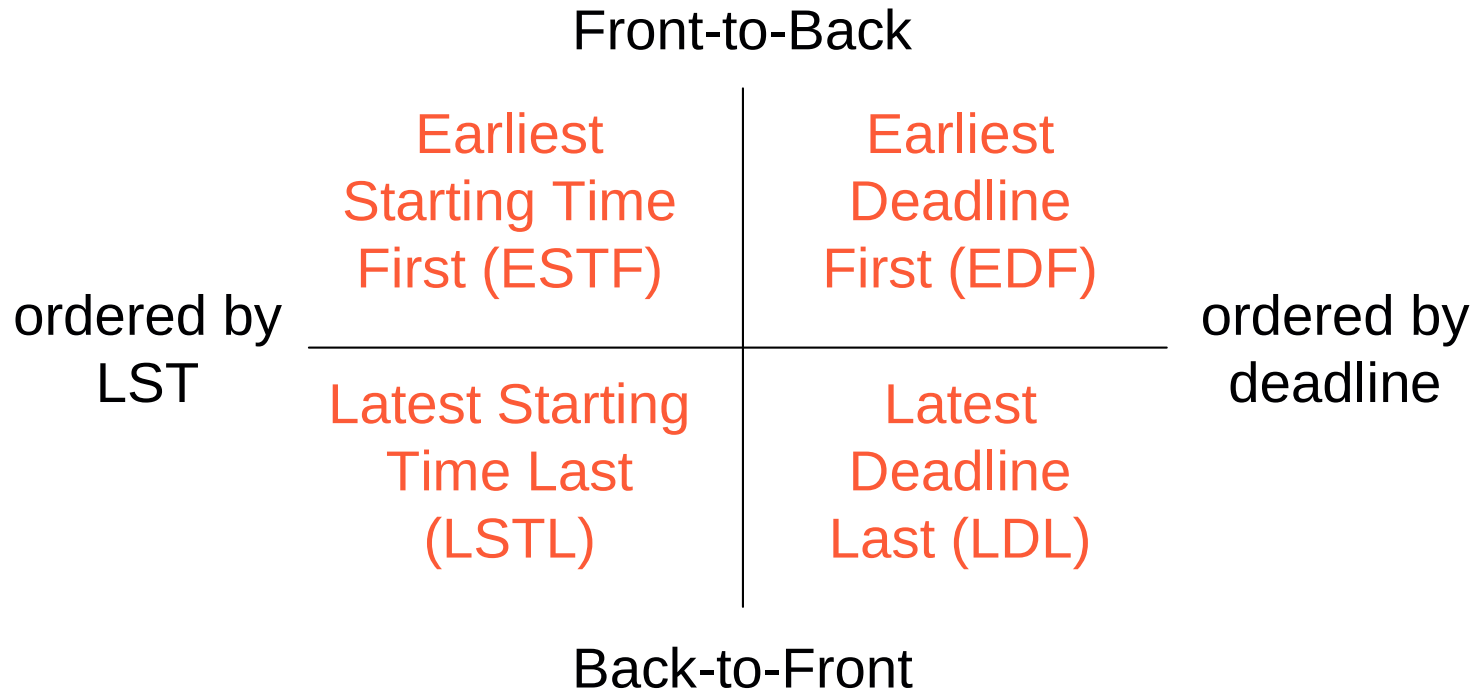
Minimum Switching Model

- Flexible Flow Shop with 3 stages
  - Load, Read, Unload
  - Uncoupled Load and Unload
- Read all data from RSM before unloading
  - Minimum number of switches
- Resource constraints to guarantee mutual exclusion

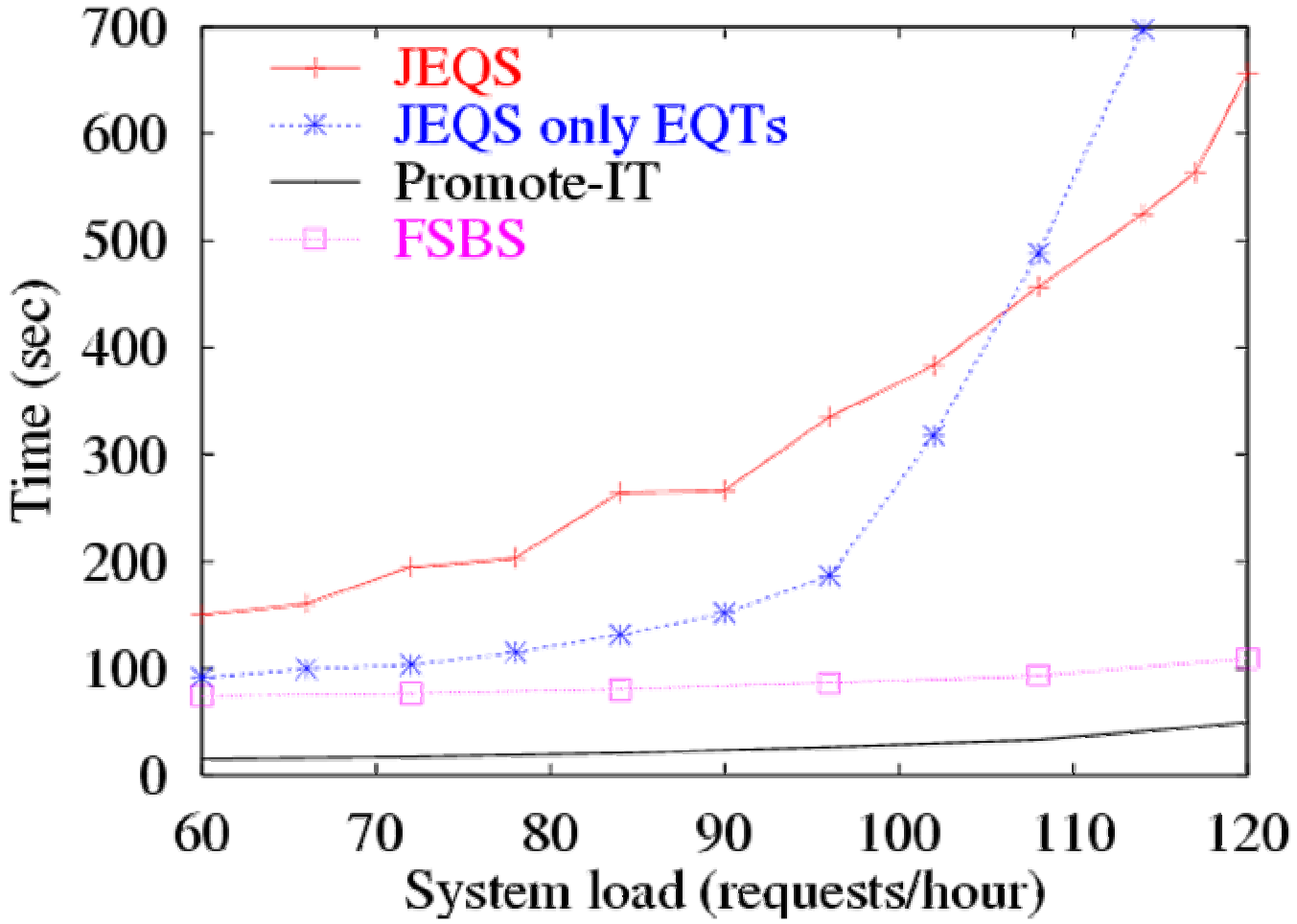
Promote-IT Characteristics

- Aperiodic scheduler
- Pipeline
- Early dispatching
- Uncoupled load and unload
- Heuristic (polynomial) scheduler
  - Branch-and-bound algorithm
  - Best-drive heuristic

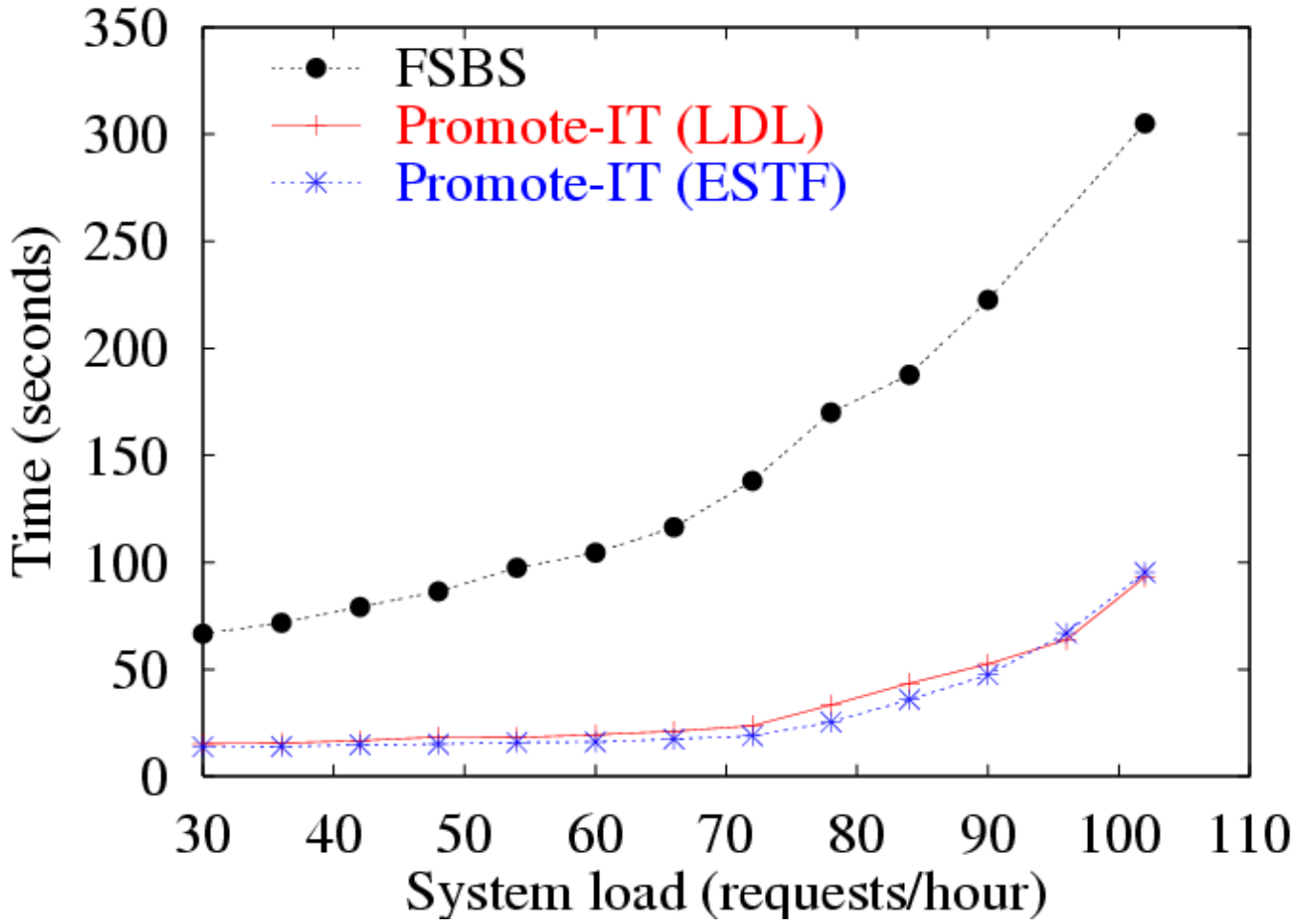
Promote-IT Scheduling Strategies



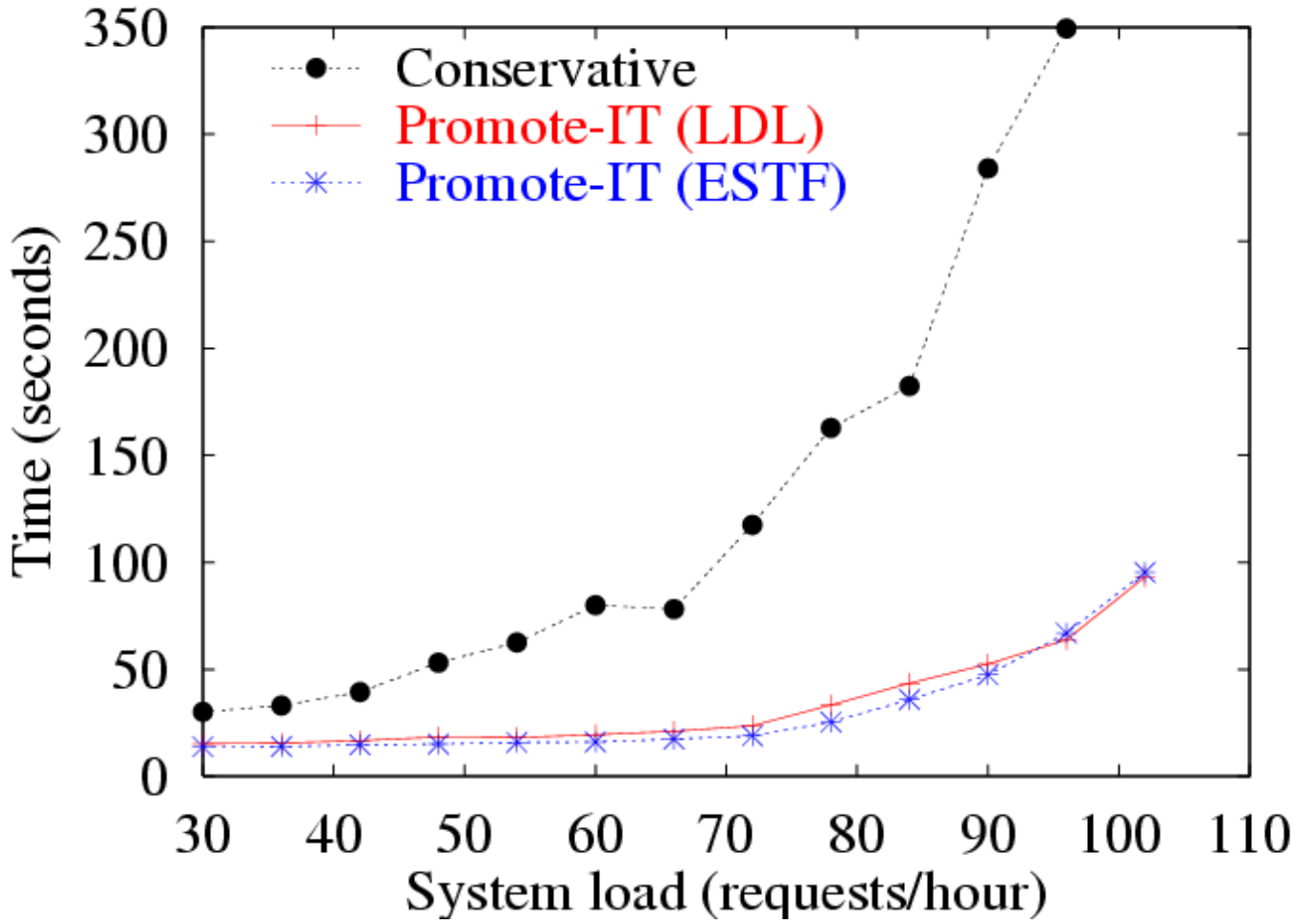
Aperiodic Scheduling



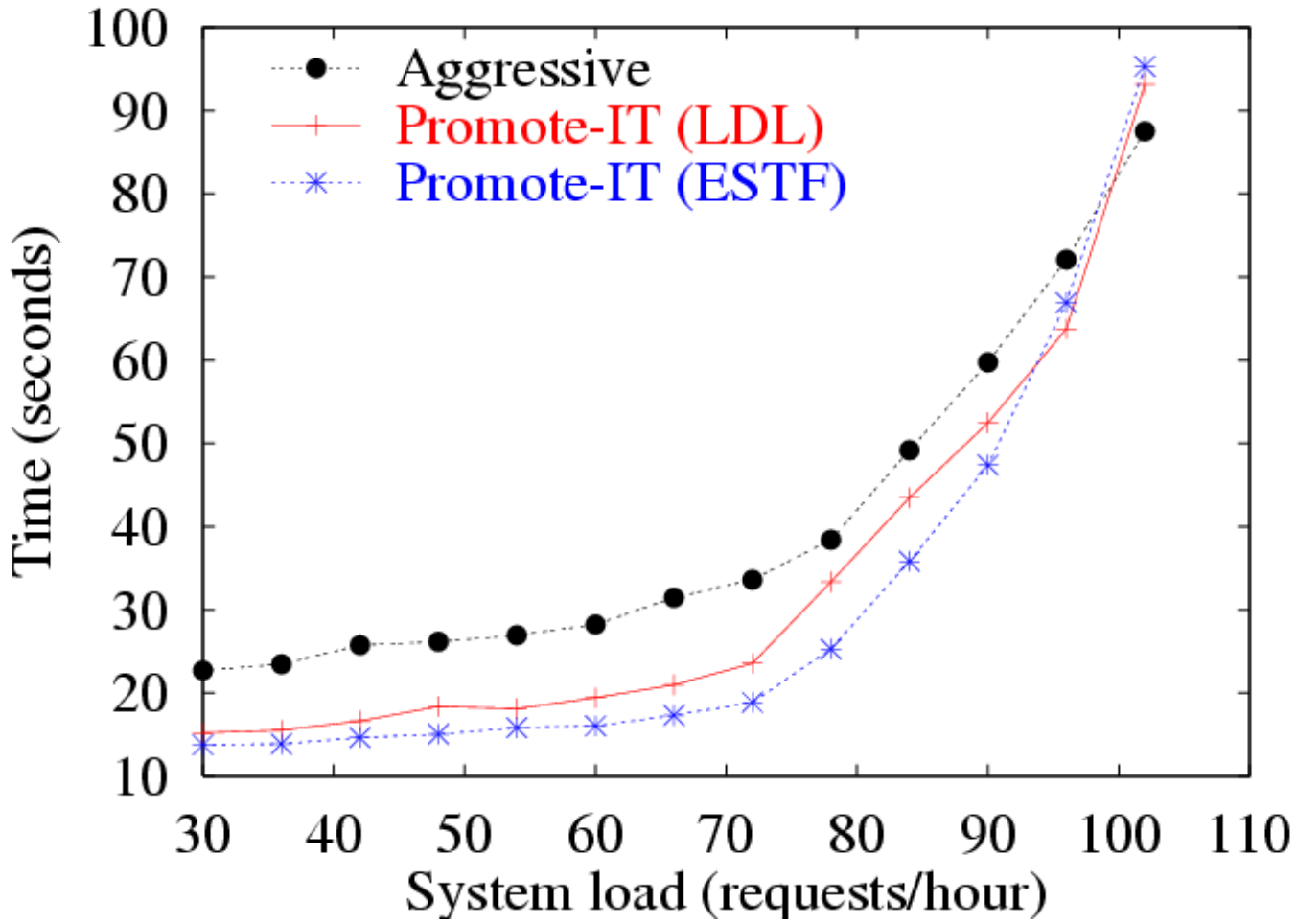
Pipelining


FSBS
Promote-IT (LDL)
Promote-IT (ESTF)
Time (seconds)
0
50
100
150
200
250
300
350
30
40
50
60
70
80
90
100
110
System load (requests/hour)

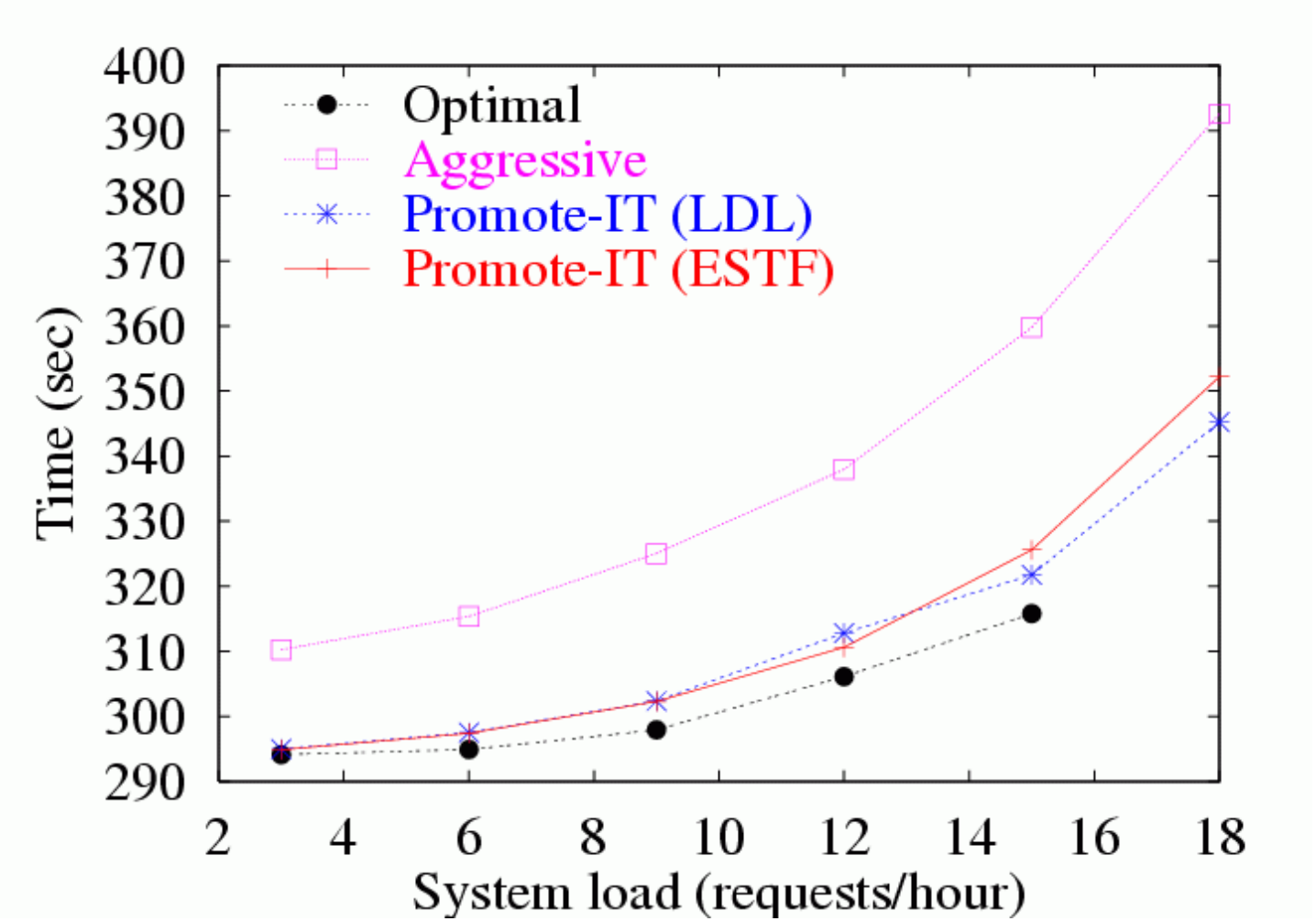
Early Dispatching



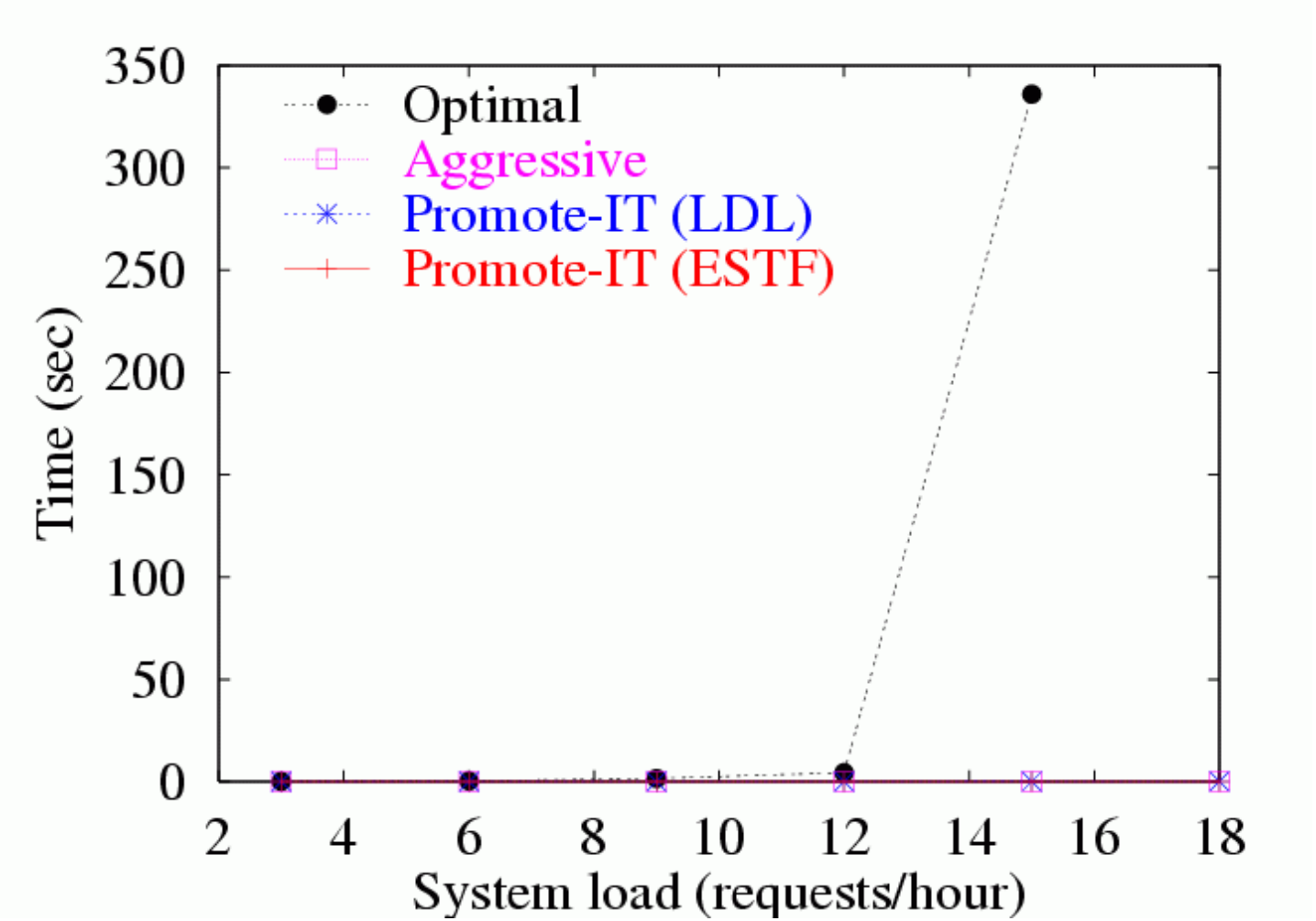
Decoupled Load/Unload



Heuristic


Optimal
Aggressive
Promote-IT (LDL)
Promote-IT (ESTF)
Time (sec)
400
390
380
370
360
350
340
330
320
310
300
290
2
4
6
8
10
12
14
16
18
System load (requests/hour)

Heuristic (Computing Time)



Conclusions

- Flexible way to access tertiary storage
- Real-time guarantees
- Promote-IT
  - Efficient polynomial scheduler
  - Better performance than other schedulers
  - Response time near optimal
  - Can handle any type of requests and jukebox hardware