A Framework for QoS-Aware Software Components

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Motivation

- Characteristics of new generation of complex software systems:
  - Highly distributed
  - Component-based
  - Service-oriented
  - Unsupervised operation
  - Hostile environments
  - Composed of a large number of "replaceable" components discovered at run-time
  - Run on a multitude of (unknown and heterogeneous) hardware and network platforms

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Motivation (cont'd)

- Enabling technologies
  - Web Services:
    - SOAP, UDDI, WSDL
  - Grid Computing
  - Peer to Peer Networks
  - Wireless Networking

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Requirements of Next Generation Software Systems

- Adaptable and self-configurable to changes in workload intensity:
  - QoS requirements at the application and component level must be met.
- Adaptable and self-configurable to withstand attacks and failures:
  - Availability and security requirements must be met.

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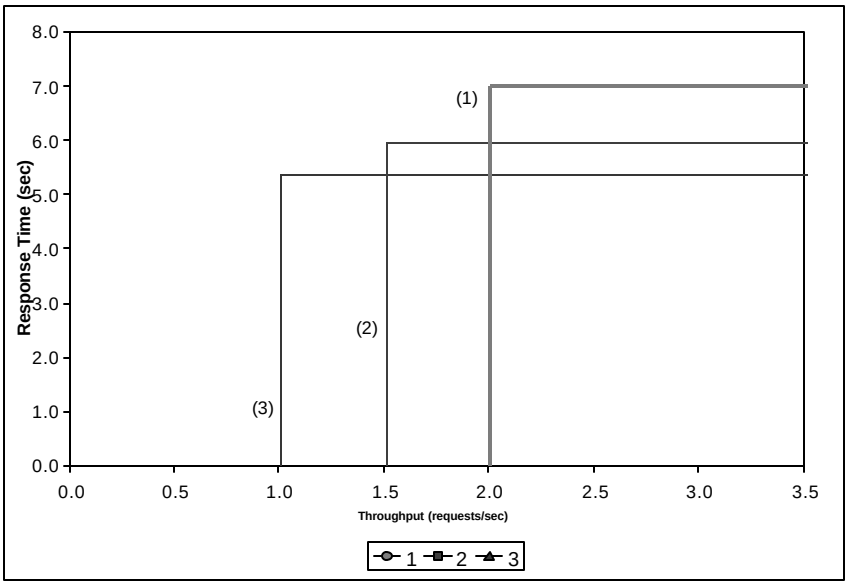
Feasibility Regions for a Q-component



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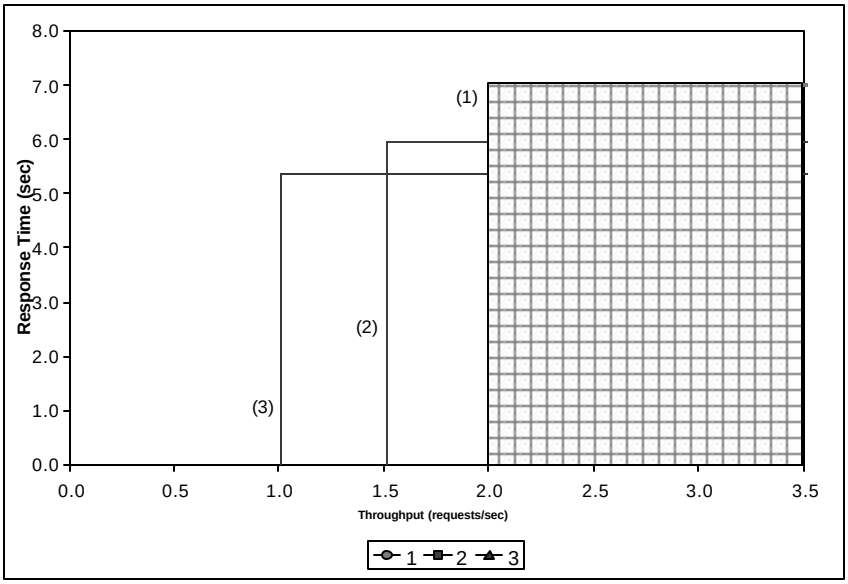

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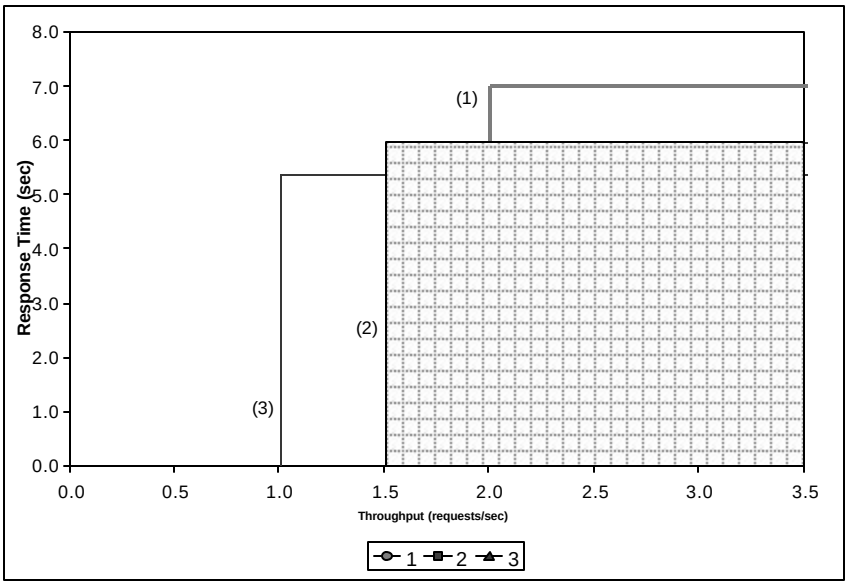
Feasibility Regions for a Q-component



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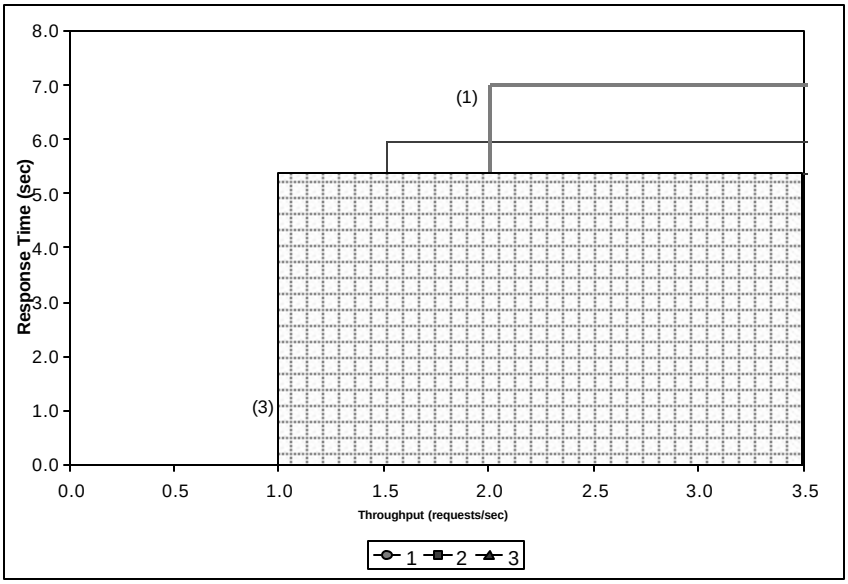
Feasibility Regions for a Q-component



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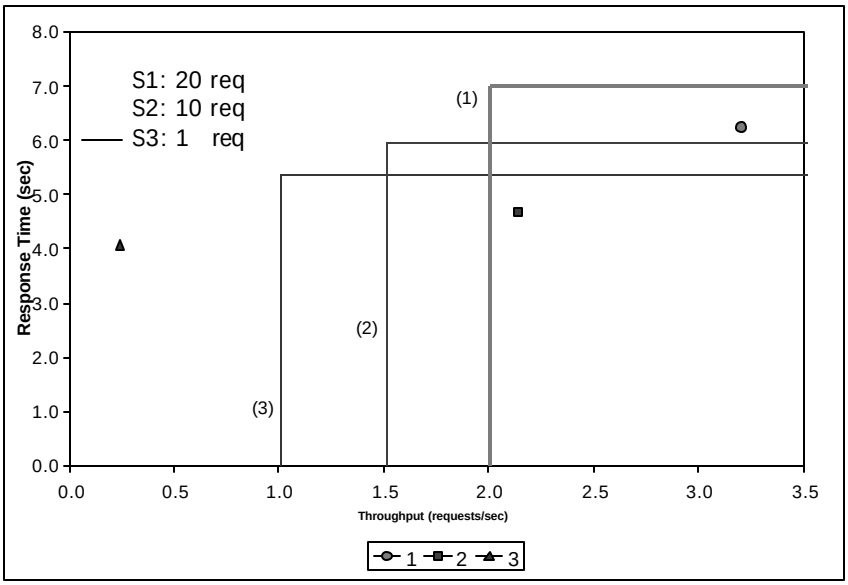
Scenario 1: not feasible



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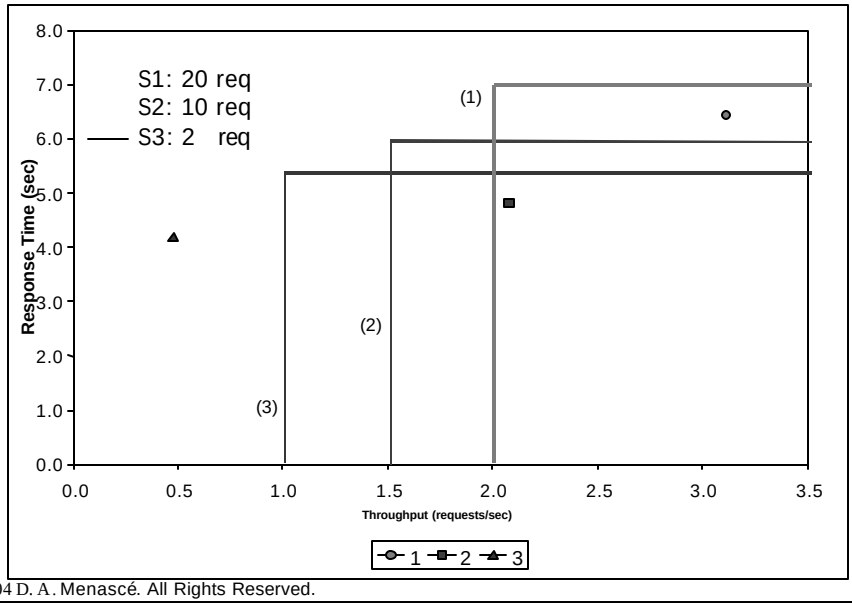

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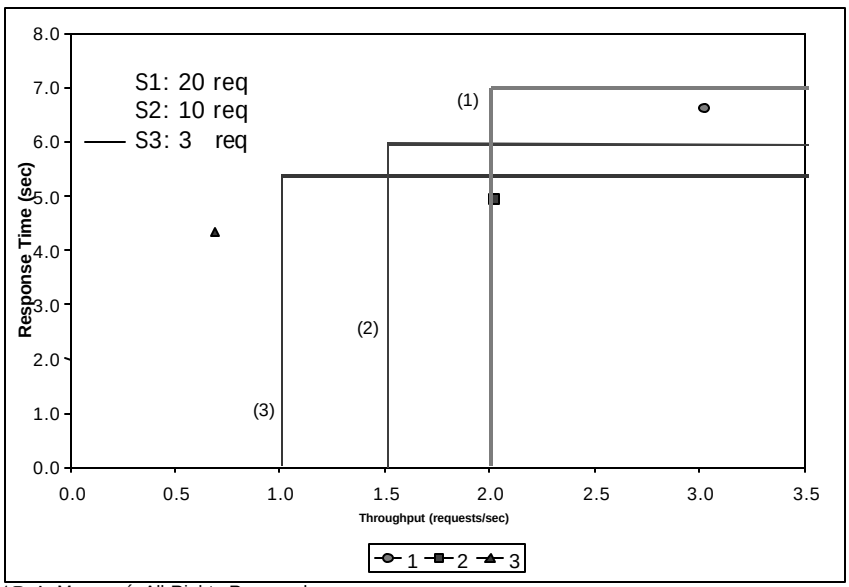
Scenario 3: not feasible



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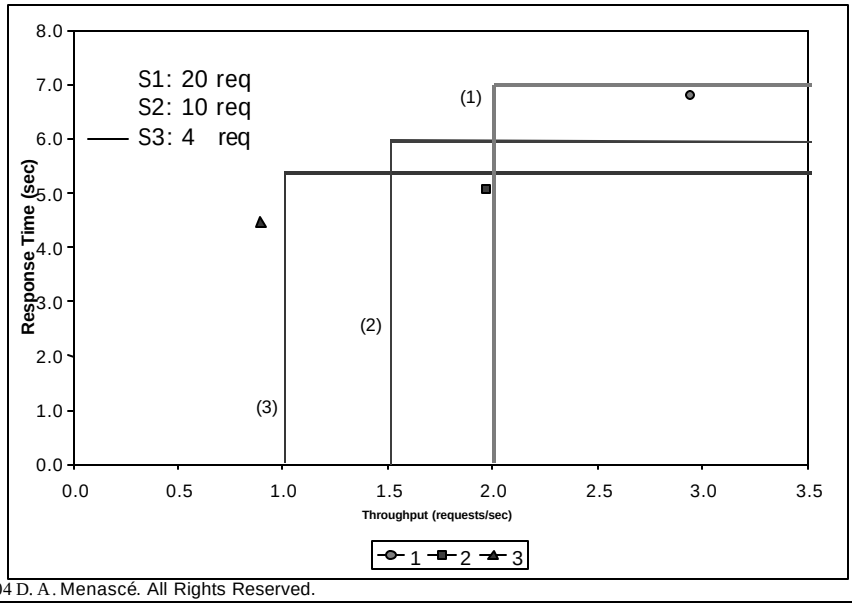
Scenario 4: not feasible



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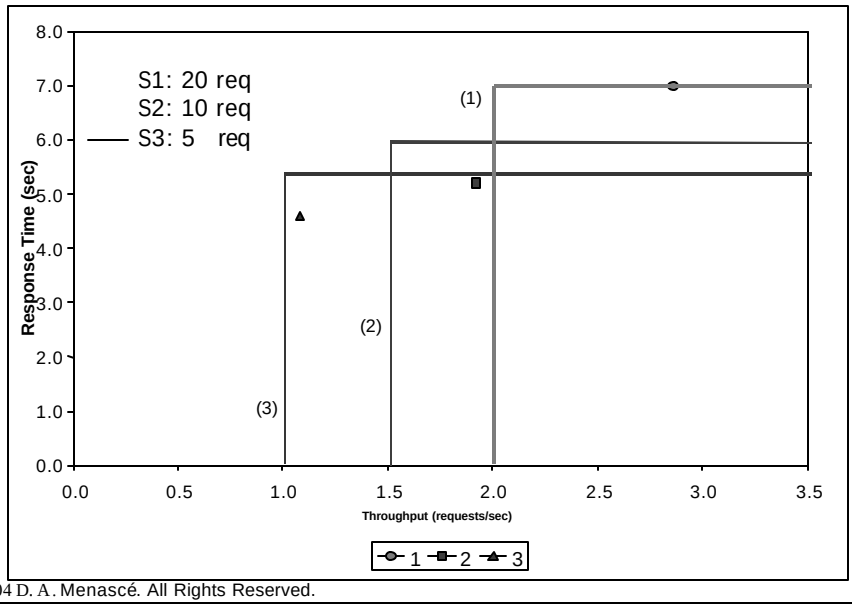
Scenario 5: feasible!



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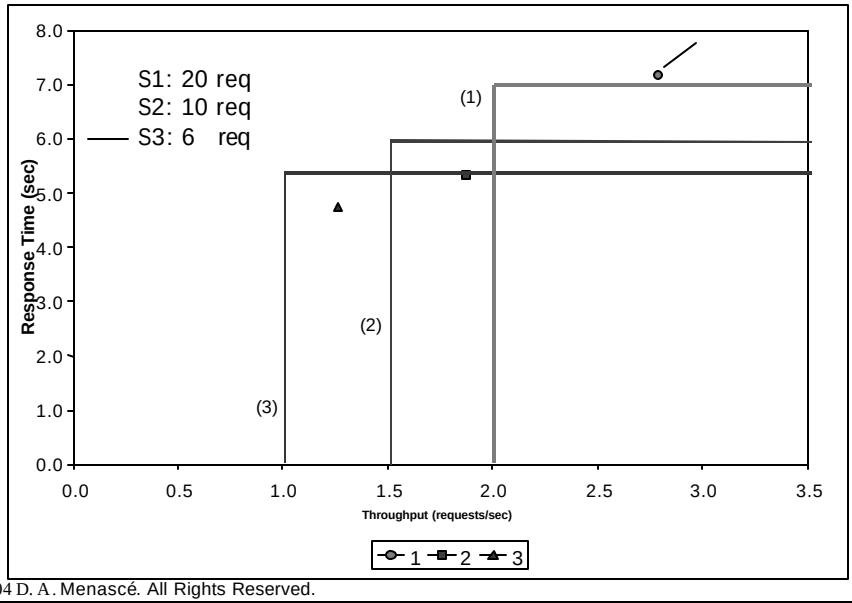
Scenario 6: not feasible again



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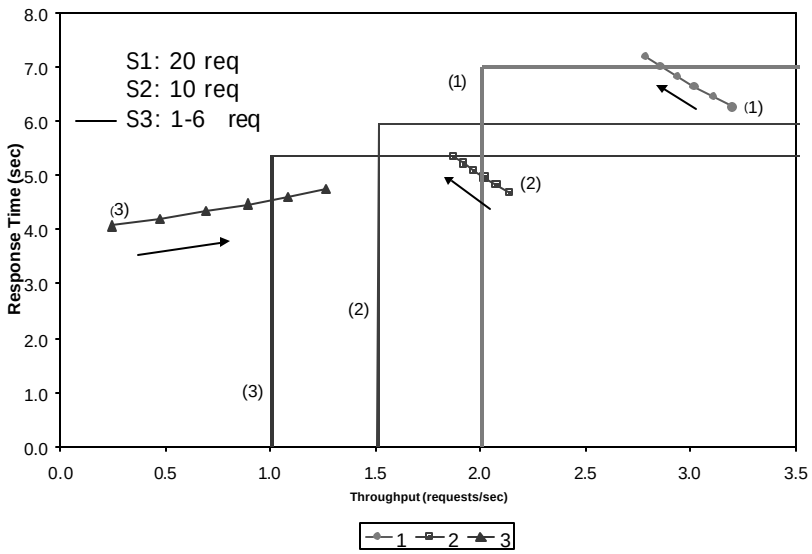
All six scenarios



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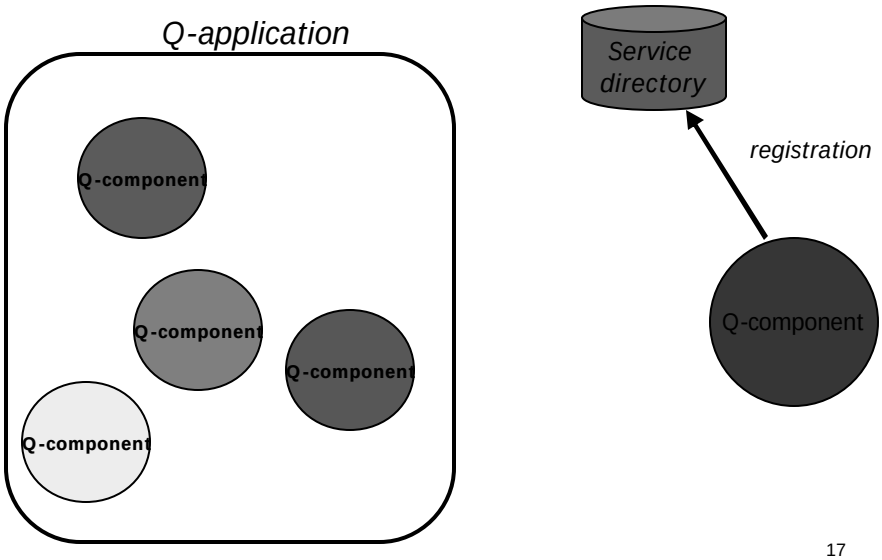
Q-Applications and Q-components



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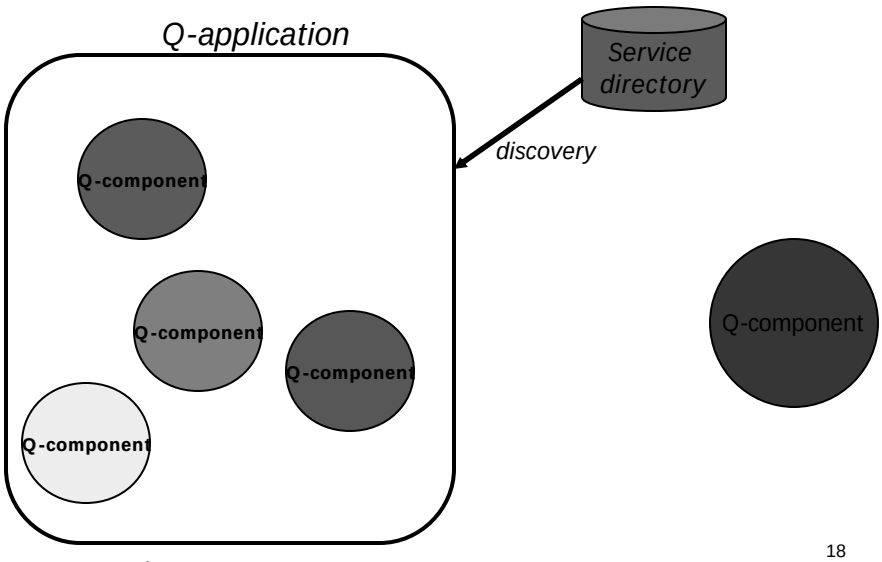
Q-Applications and Q-components



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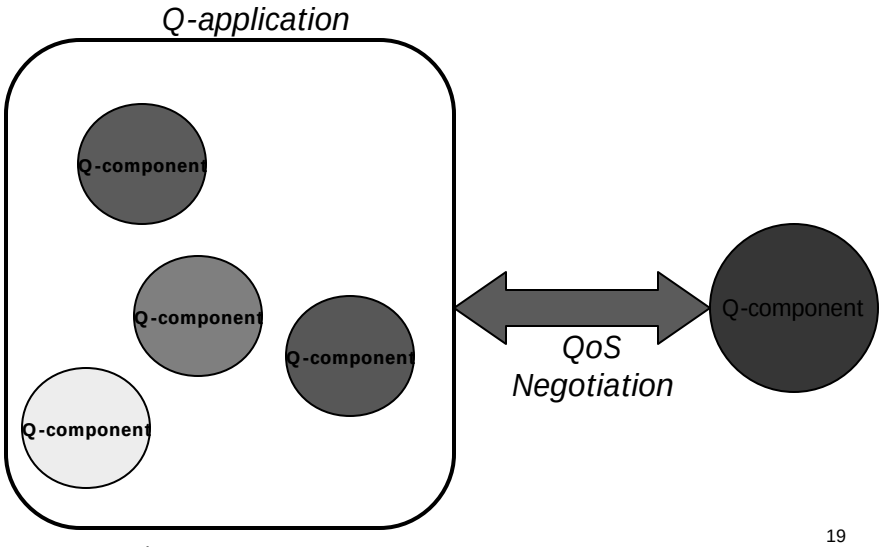
Q-Applications and Q-components



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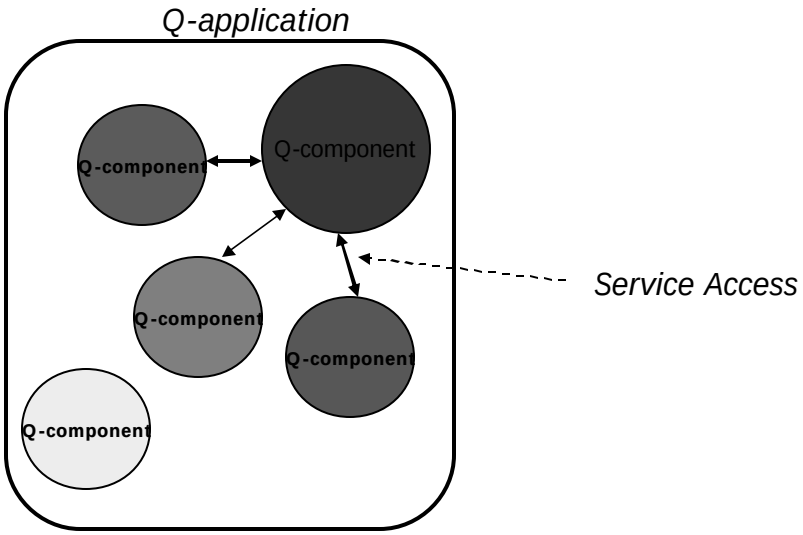
Q-Applications and Q-components



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QoS-Aware Software Components: Q-Components

- Engage in QoS Negotiations (accept, reject, counter-offer)
- Provide QoS guarantees for multiple concurrent services
- Maintain a table of QoS commitments
- Service dispatching based on accepted QoS commitments
- Q-components are the building blocks of QoS-aware applications

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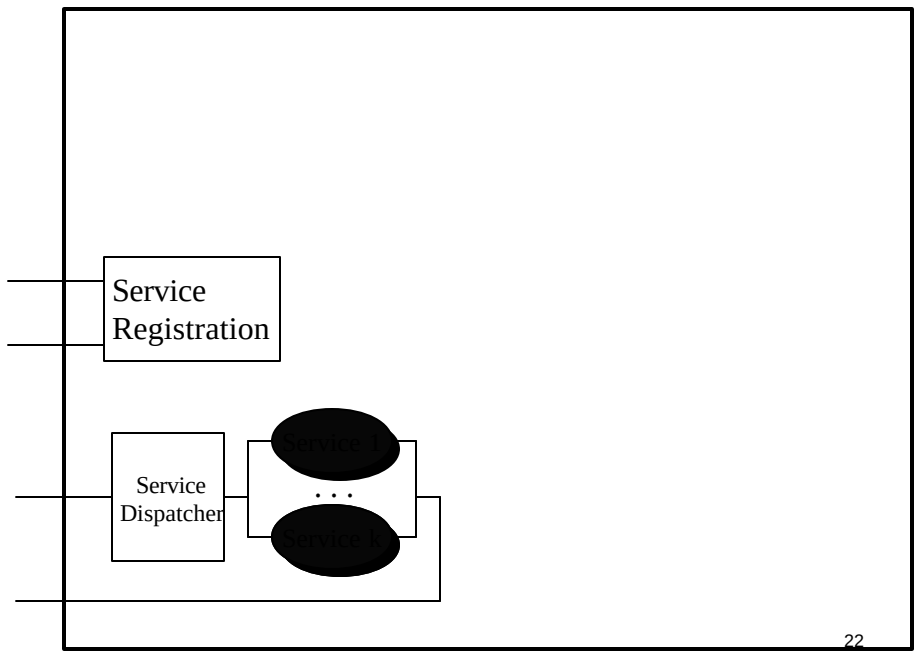
Architecture of a typical software component



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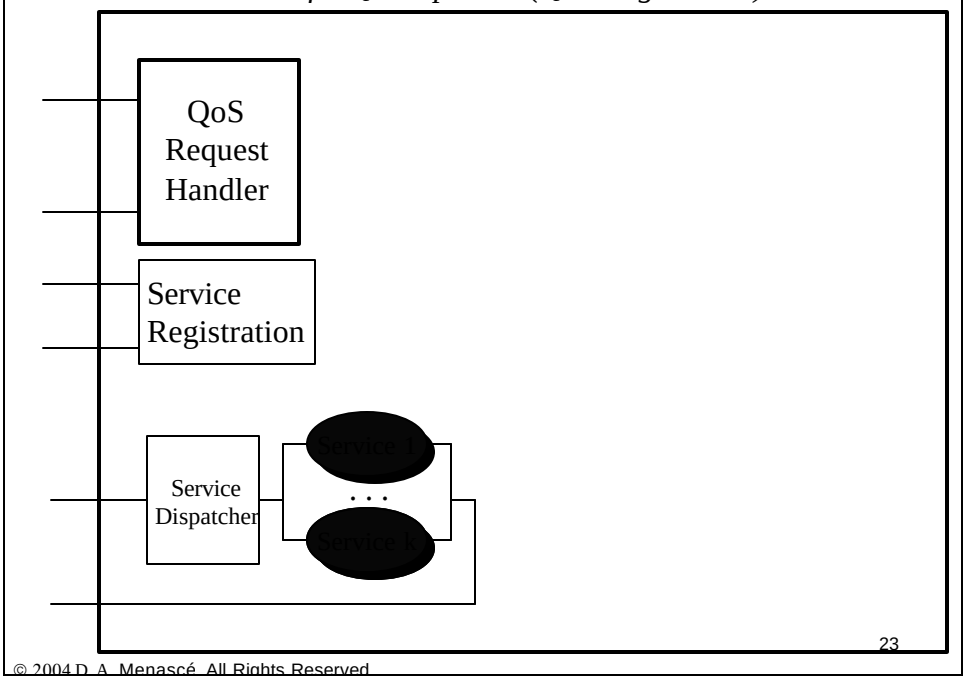
Architecture of a Q-component (QoS Negotiation)



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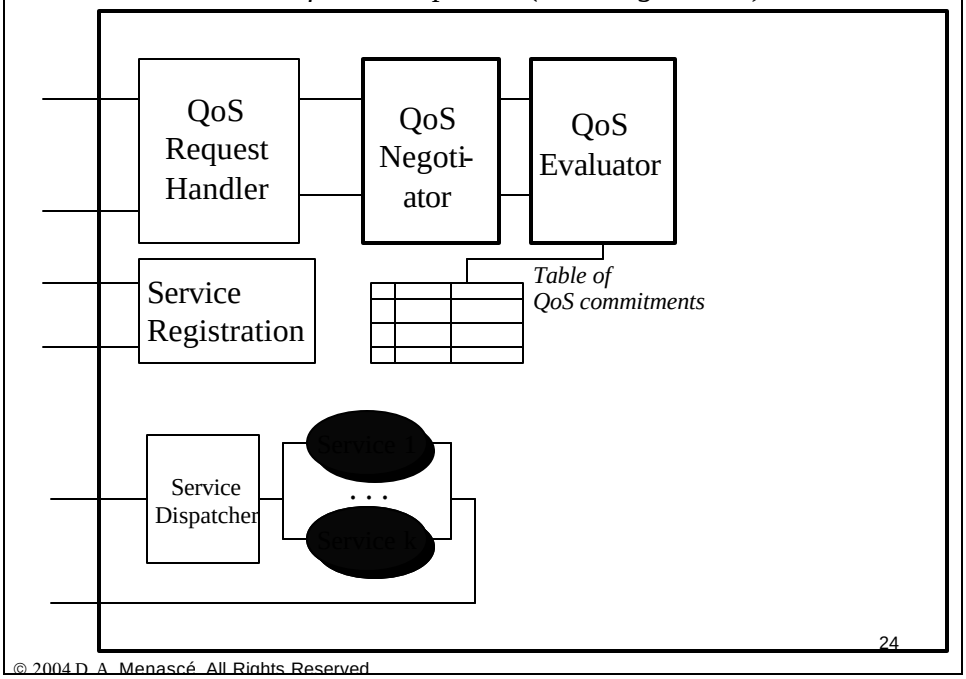
Architecture of a Q-component (QoS Negotiation)



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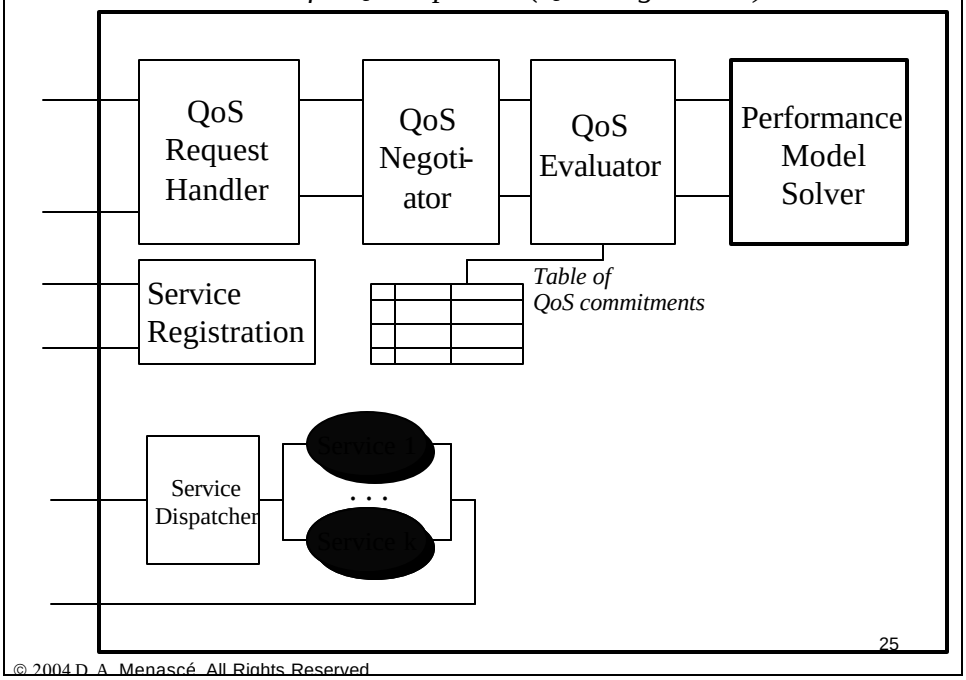
Architecture of a Q-component (QoS Negotiation)



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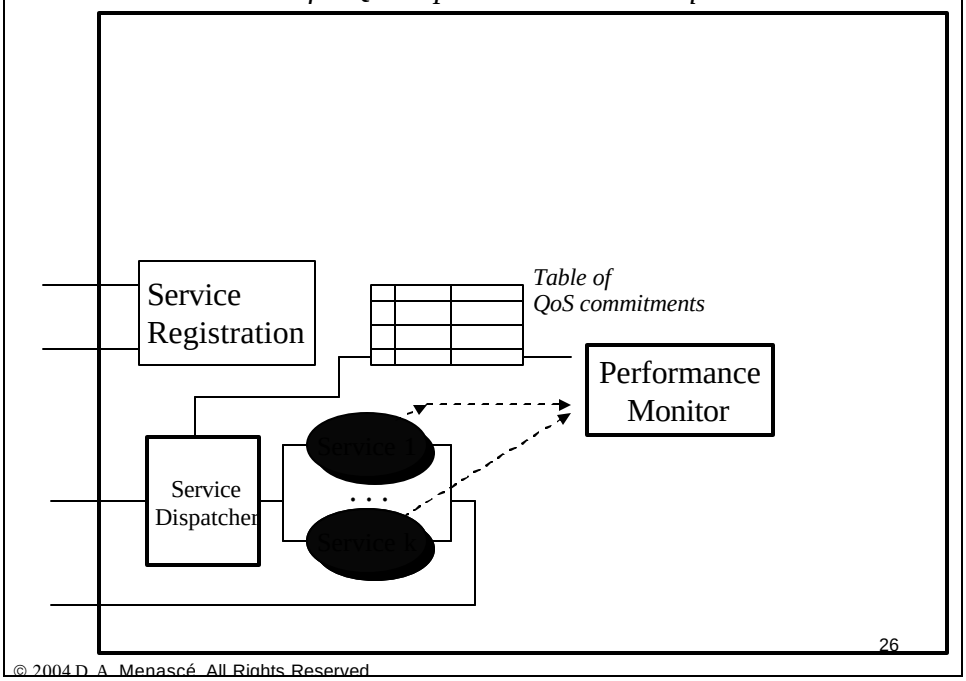
Architecture of a Q-component –Service Requests



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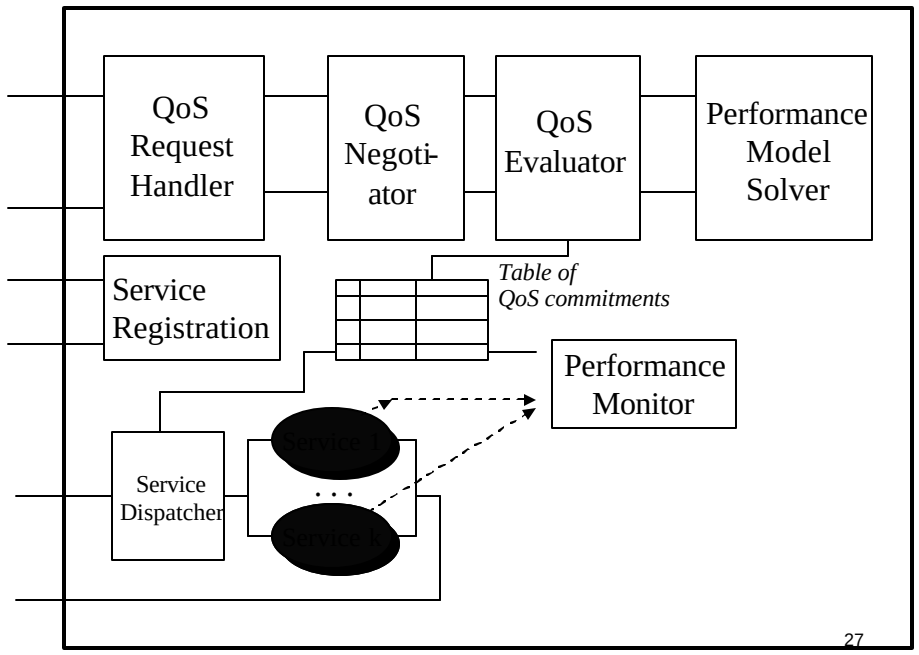
Architecture of a Q-component



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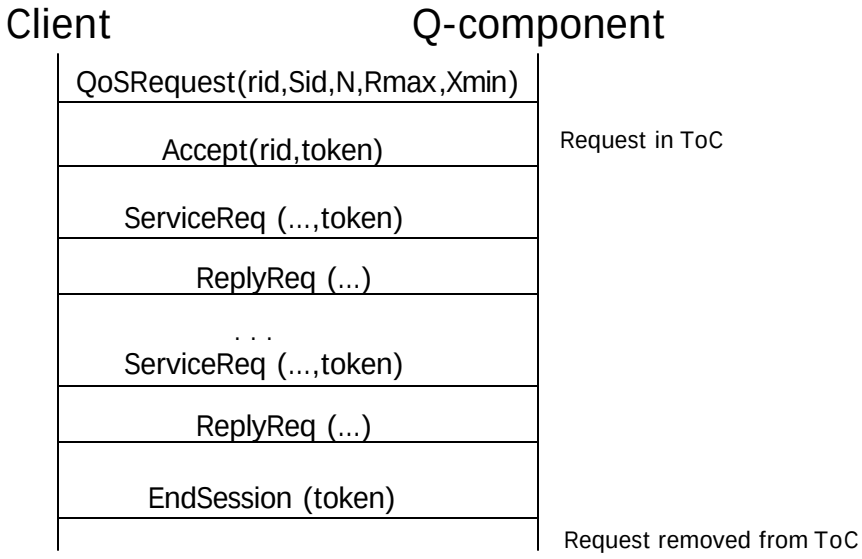
Successful QoS Negotiation



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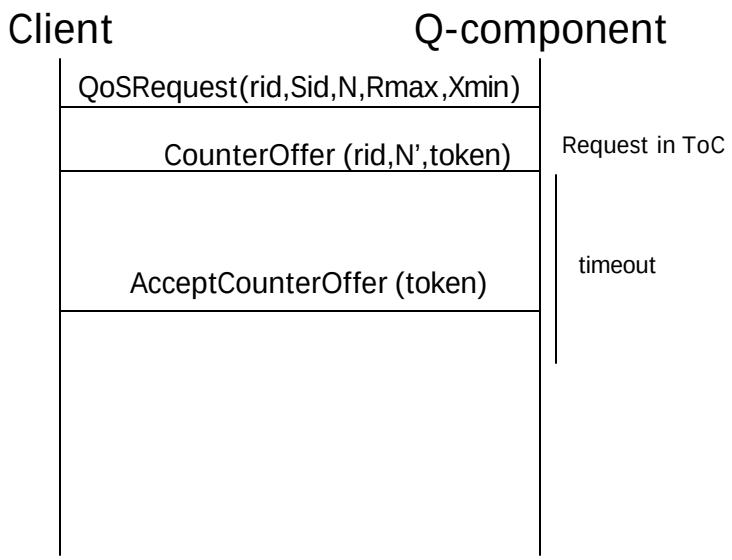
On-time Accepted Counteroffer



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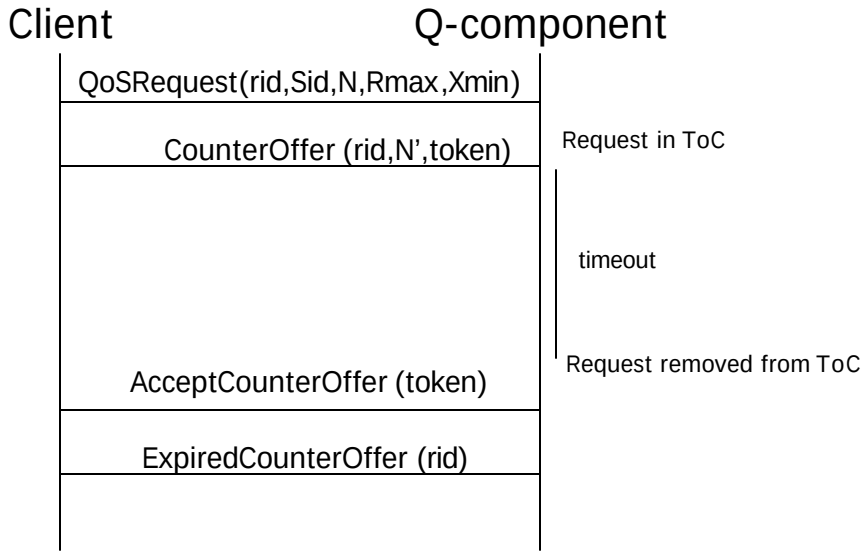
Expired Accepted Counteroffer



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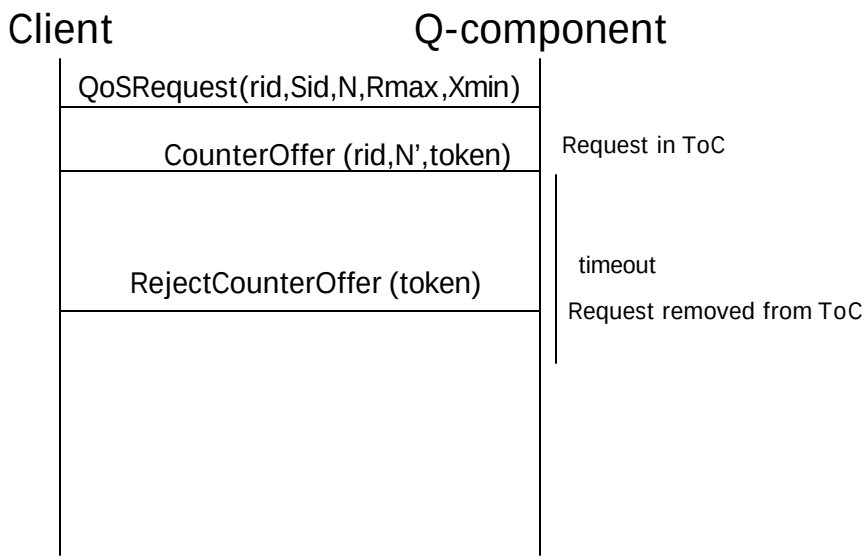
Rejected Counteroffer



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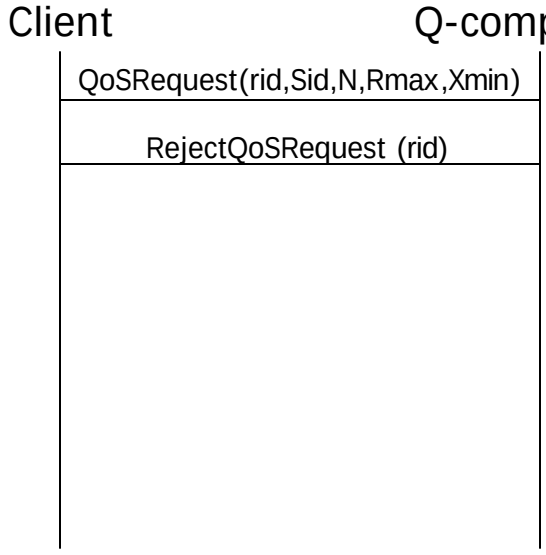
Rejected QoS Negotiation



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Decision Table for QoS Negotiation

1. Current and other requests are satisfied				Accept
2. Only Current is Violated				
Reason	Remedy	Current	Others	Decision
Only MAXR is violated	Decrease N	OK	OK	Counter Offer
		Not OK: MINX is violated or N=0	OK	Reject
Only MINX is violated	Increase N	OK	OK	Counter Offer
		OK	Not OK	Reject
		Not OK & MAXR is violated	OK	Reject
		Not OK & MAXR is violated	Not OK	Reject
MINX & MAXR are violated	Decreasing N reduces X and increasing N increases R. So, there is no solution.			Reject
3. Current Request and Others are Violated				
Reason	Remedy	Current	Others	Decision
Only MAXR is violated	Decrease N	OK	OK	Counter Offer
		OK	Not OK	Reject
		Not OK: MINX is violated or N=0	OK or not OK	Reject
Only MINX is violated	X could be increased by increasing N. But this would further violate the QoS of other classes.			Reject
MINX & MAXR are violated	Decreasing N reduces X and increasing N increases R. So, there is no solution.			Reject
4. Only Other Requests are Violated				
Reason	Remedy	Current	Others	Decision
Any	Decrease N	OK	OK	Counter Offer
		OK	Not OK: N=1 but others still violated	Reject
		Not OK: MINX violated or N=0	OK or not OK	Reject

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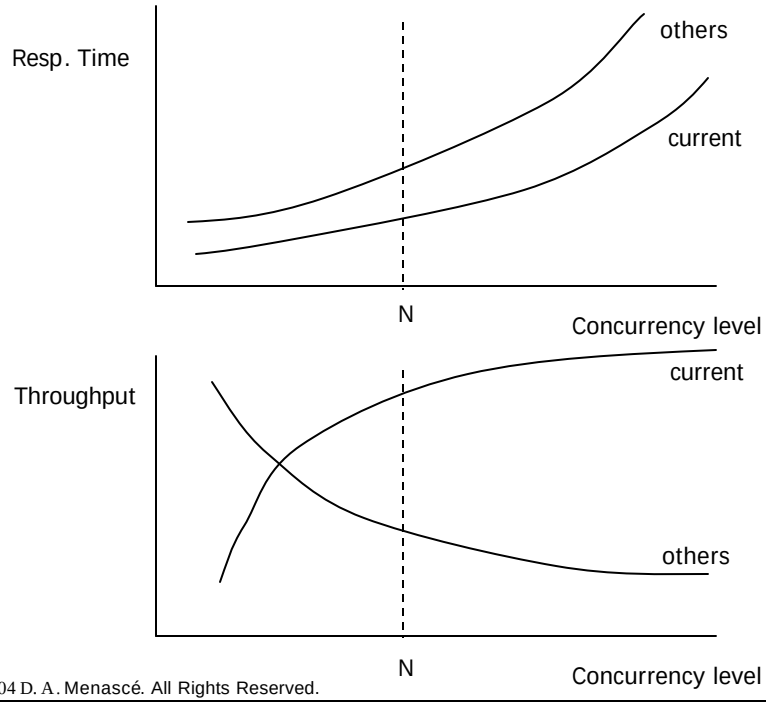

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Building a Performance Model

New Request: Sid = 3, N = 12

Base Matrix of Service Demands (in msec):

	Service		
	1	2	3
CPU	25	34	20
Disk 1	30	50	24
Disk 2	28	42	31

Table of Commitments (ToC):

Commitment ID	Service ID	N	…
1	2	10	…
2	3	15	…
3	1	8	…
4	1	20	…
5	2	13	…

Matrix of Service Demands (in msec)

	Class					
	1	2	3	4	5	6
CPU	34	20	25	25	34	20
Disk 1	50	24	30	30	50	24
Disk 2	42	31	28	28	42	31
Vector N:	10	15	8	20	13	12

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3	1	8	…
4	1	20	…
5	2	13	…

Matrix of Service Demands (in msec)

	Class					
	1	2	3	4	5	6
CPU	34	20	25	25	34	20
Disk 1	50	24	30	30	50	24
Disk 2	42	31	28	28	42	31
Vector N:	10	15	8	20	13	12

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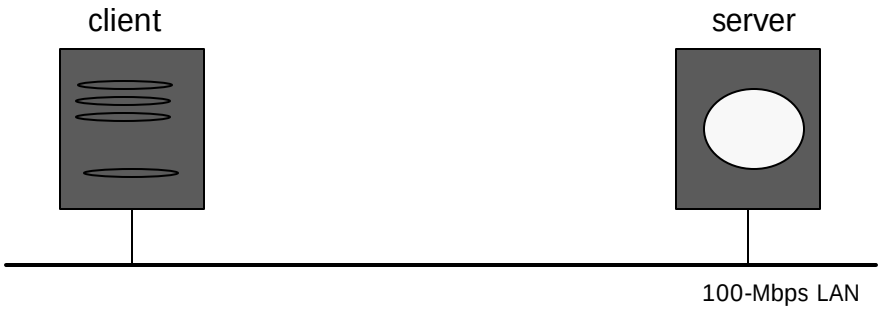
Experimental Setup



- 15 client processes.
- Each client process generates 20 sessions.
- Each session forks 10 threads.
- Each thread sends 5 service requests.

- Q-component.
- 3 services

A random workload is generated and submitted to a non-QoS component. The workload is recorded and replayed against a Q-component.

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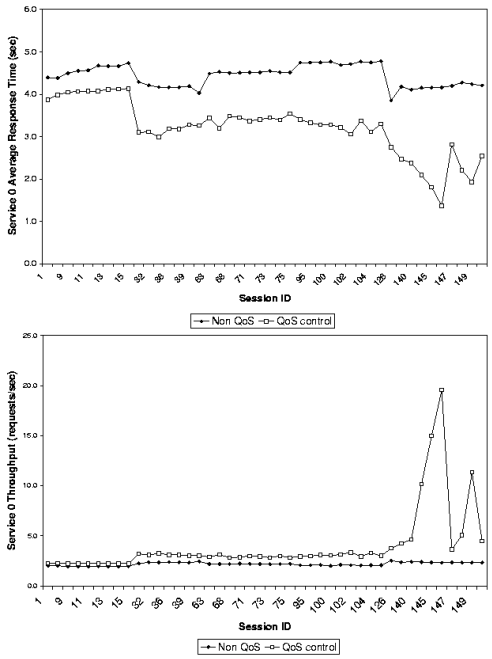
Service 0 Results:



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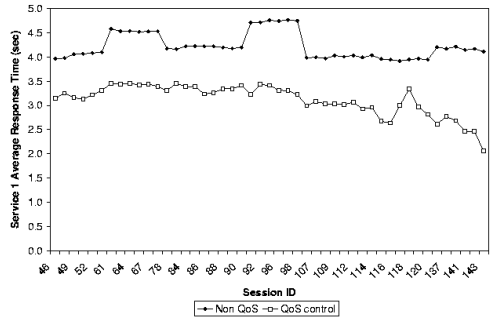
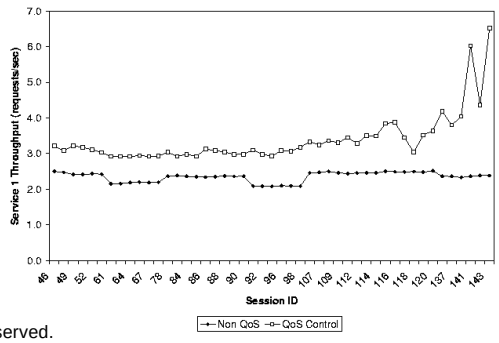
Service 1 Results:





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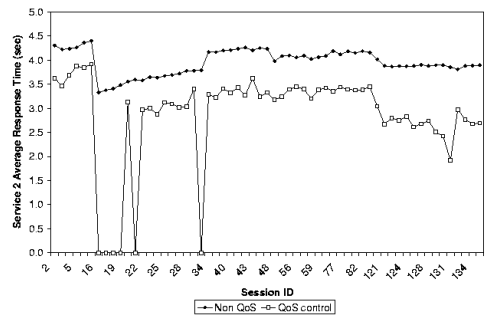
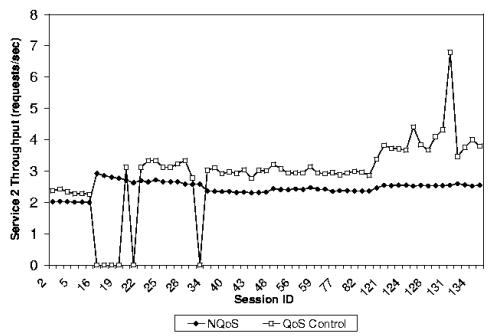
Service 2 Results:





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f = 0.0				
Svc No.	No. Dropped Sessions	No. of Sessions	% Drop	% Resp. Time Reduction
0	24	440	5	11
1	19	470	4	9
2	59	590	10	7
Total	102	1500	7	9
f = 0.10				
Svc No.	No. Dropped Sessions	No. of Sessions	% Drop	% Resp. Time Reduction
0	52	440	12	21
1	66	470	14	16
2	148	590	25	12
Total	266	1500	18	16
f = 0.25				
Svc No.	No. Dropped Sessions	No. of Sessions	% Drop	% Resp. Time Reduction
0	92	440	21	28
1	140	470	30	26
2	263	590	45	20
Total	102	1500	33	24

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Concluding remarks

- A validated framework for QoS-aware software components that do admission control and resource reservation.
- Analytic performance models can be very useful and efficient in QoS negotiation.
- QoS negotiation overhead did not exceed 10% of the CPU service demand.

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Ongoing Work

- Self-configurable component based software:
  - Experiments with different QoS negotiation approaches
  - QoS-aware applications
  - Include cost in the QoS negotiation
  - Case of components invoking other components.

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