

QORE
QoS and Resource Optimization in the Internet

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QORE
Structure

- Motivation
- QoS and Resource Optimisation Goals
- QORE Optimization Algorithms
- QORE Architectural Design and Scenarios
- Ongoing Work – Intermon
- Summary

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Motivation

Requests for next generation networks fix/mobil

- **QoS All-IP Network** (QoS Signalling, IPv6, Intser/DiffServ Basis)
- Mobile Middelware-Plattform
- User Profiling
- Middelware Plattform for mobile Applications (open API's)
- Multicast / Streaming
- Security / PKI
- Location based services
- **Support of different Service Provider**
- Adaptation of Applications (XML)

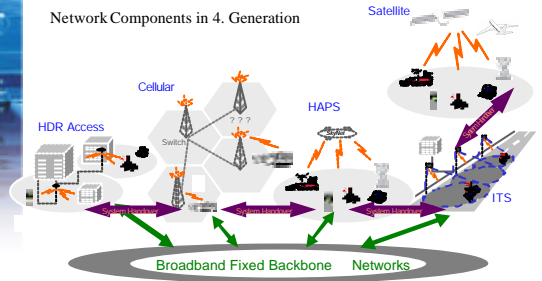
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QORE Motivation

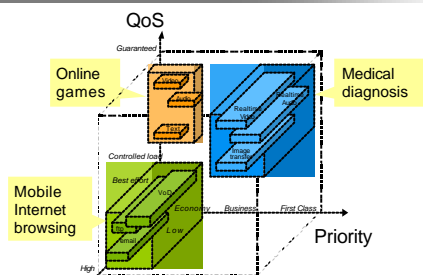
Network Components in 4. Generation



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IP QoS for mobile Applications



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Trends mobile Communication 1(3)

- Interactive user terminal (vs. burglar alarm or webcam)
- Personal terminal (vs. car, office, home)
- "Real reality" (vs. virtual reality)
- 100 kbits everywhere (vs. 100Mbits somewhere)
- Several visual input types (one-handed, pen, keyboard)
- Multiservice terminals (PS+CS, purse, GPS, FM radio, ...)
- Extensions to cellular (WLAN, BlueTooth, ...)



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Trends mobile Communication 2(3)

- Color screen
- Built-in battery
- FM radio
- MP3 audio
- Video
- PKI security
- Location (GPS and cellular)
- Voice recognition and control
- Personal area networks (BlueTooth)

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Trends mobile Communication 3(3)

Isolated service sets

- sequential service for cellular (phone, fax, ...) and IP (WAP, Web, email, ...)
- terminal: unified user interface, isolated stacks
- infra: radio capacity sharing, user-initiated IP connectivity, cellular push

Integrated service sets

- parallel service for cellular and IP (e.g. WAP and GSM voice)
- integrated service for cellular and IP (e.g. WTA and GSM voice)
- terminal: "pre all-IP" user interface
- infra: radio coordination, PS control plane for CS user plane

All-IP service set

- IP traffic evolution: bursty + streaming + real-time voice&video
- key requirements: fast session set-up, push, QoS (handover, delay, jitter)

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Motivation – different kind of QoS requirements

- Elasticity
- Sentience
- Autonomy
- Large scale
- Time criticality
- Safety criticality
- Geographical dispersion
- Mobility
- Evolution

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Motivation – need for QoS optimisation derived from:

- QoS tuning and adaptation for application and traffic classes
- QoS/SLAs specification and monitoring of applications or traffic QoS parameters
- QoS based adaptive resource control for different traffic classes
- Bandwidth Brokerage (BB) for QoS and resource mapping
- DiffServ traffic classes and corresponding SLAs and QoS requirements
- Measurement Based Admission Control
- Inter-domain QoS analysis and traffic
- Backbone traffic engineering

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Usage areas for QoS and resource optimisation

- **operational performance management**
- **> Optimisation of resource allocation for QoS enabled applications and Value added Virtual Private Networks at router access points (border router, IXP, peering points, core and edge router)**

network planning

- **> Simulation of different strategies for resource reservation based on one of the research techniques considering different**

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Structure

- Motivation
- QoS and Resource Optimisation Goals
- QORE Optimization Issues
- QORE architectural design and scenarios
- Ongoing Work – Intermon
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Network Planning and QoS Optimisation

Optimisation of QoS and resource reservation levels of elastic applications i.e. applications with different levels of QoS support and resource requirements

Elasticity and Rate type	Descriptions
Stream	Predictable delivery at a relatively constant bit rate (CBR). For example, although their rates often fluctuate, audio and video data streams are considered CBR because they have a quantifiable upper boundary.
Burst	Unpredictable delivery of "blocks" of data at a variable bit rate (VBR). Applications like file transfer move data in bulk that can increase data rate to use all available bandwidth (no upper bound).

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Operative Performance Management and Optimisation

QoS and resource optimisation combined with operative control

- effective bandwidth
- management of bandwidth (Bandwidth Brokers)
- measurement based admission control
- traffic and QoS model predictions

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Operation research methods for QoS and resource optimisation

Goal function
optimal QoS level of applications and cost efficient resource assignment

Communication jobs with restrictions on

- Durations (time characteristics and synchronisation),
- Multiplexing
- Timing dependencies
- levels of QoS and resource reservation
- cost

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Application of optimisation techniques and algorithms for QoS and resource optimisation

Use of different operation research methods to solve the problem of optimal resource assignment of QoS enabled applications considering specific resource and QoS restrictions of communication jobs

- Assignment problem,
- Critical path method,
- Max flow problem,
- Shortest path,
- Transportation, cost flow problems

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Restrictions for operation research methods

elastic stream applications

Delay or rate elasticity

levels of bandwidth reservation

Maximum Delay / minimum rate threshold -> minimum level of bandwidth reservation

elastic data transfer (burst) applications

duration NOT dependent on bandwidth reservation and QoS level

Throughput elasticity

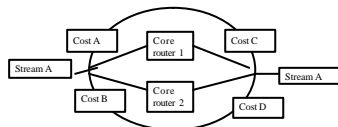
levels of bandwidth reservation

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Timing and cost restrictions



framework

IP based accounting and QoS based routing RFC 2386

Cost dependency of timely usage of resources

characterising resource requirements of QoS based application

Minimisation of cost based resource usage

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Optimization considering timing requirements

ptimal resource assignement for QoS based applications with different time requirements

ime requirements of multimedia and distributed application:

- same start, end and duration: multiplexed multimedia applications – multimedia conferences
- start / end / duration relationships: distributed applications
-

lexible start time and same end time: time dependent content applications

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QORE Optimization research problem

Parameter Restrictions

1. Time Restrictions of communication jobs

- start synchronisation
 $S_k = S_l$, $k=1, \dots, n, l=1, \dots, n, n \leq N$
where S_k, S_l start time of job k , resp. l
- multimedia multiplexing
 $D_k = D_l$, $k=1, \dots, r, l=1, \dots, r, r \leq N$
where D_k, D_l duration of job k , resp. l
- precedence relation
 $S_k > E_l$, $k=1, \dots, n, l=1, \dots, n, n \leq N$
where S_k start time of job k , E_l end time of job l
- end synchronisation
 $E_k = E_l$, $k=1, \dots, n, l=1, \dots, n, n \leq N$
where E_k, E_l start time of job k , resp. l

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QORE Optimisation - Parameter restrictions

Elasticity restrictions

different QoS levels

$$\min \leq Q_k \leq Q_{\max} \quad k=1, \dots, N$$

Where Q_k – QoS level of job k ,

Q_{\min} – minimum QoS level threshold

Q_{\max} – maximum QoS level threshold

Cost vector restrictions

different resource levels

$$\min \leq C_k \leq C_{\max} \quad k=1, \dots, N$$

Where C_k – cost of job k , resource level

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QORE Optimization -- Goal Function

Maximisation of the total efficiency metric E as sum of efficiency metric of particular jobs

Efficiency metric is defined to consider QoS, resource levels and cost vector requirements of jobs (applications)

$$E = \sum_{i=1}^N E_i$$

$$\text{Where } E_i = (D_i \times Q_i) / (C_i \times R_i)$$

E_i – efficiency metric of job i
 D_i – duration of job i
 Q_i – QoS level of job i
 C_i – Cost level of job i
 R_i – Resource level of job i
 N – Number of jobs

Where the global resource restriction GR is fulfilled

$$- R = \text{Sum of } (R_i \times D_i) \leq GR$$

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QORE architecture goals

Measurement based QoS and resource optimisation based on operation research approach

QoS and resource optimisation as input for

modelling and simulation of QoS and resource environments

Operative management and control of resources and application traffic in Internet

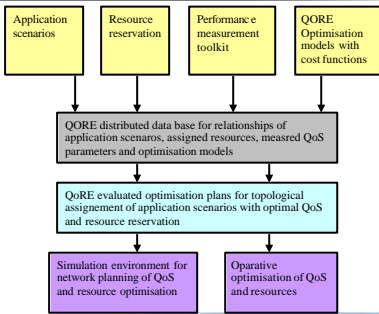
Integration of tools using distributed data base

QoS parameter measurement dependent on applications

Resource assignment using access channel approach

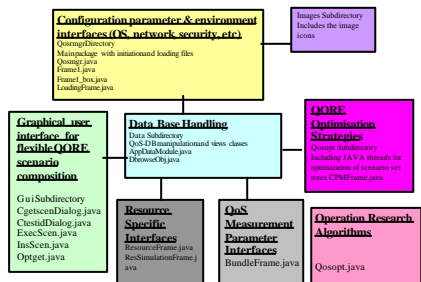
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QORE System – Architectural Design

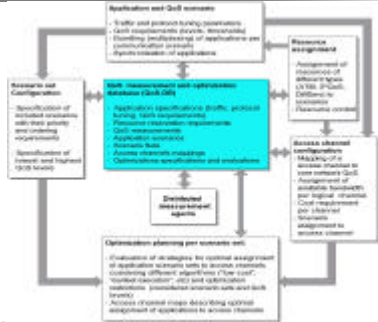


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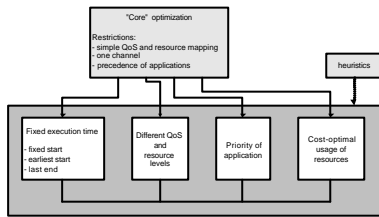
QORE Components



QORE Tools Interfaces



Concept of QORE optimization algorithms



QORE Optimization

Optimization algorithms consider the restrictions

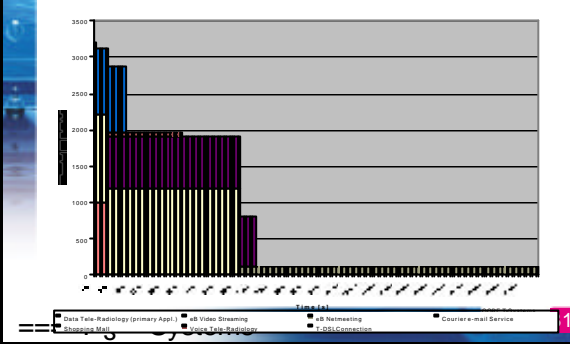
- QoS levels and QoS tuning. The mapping of application QoS levels to network resources of the access channels is done considering the measurements stored in the data base.
- Time-dependent costs for usage of access channels
- Scenario characteristics
- Timing relationships (precedence)
- Priorities of applications and scenarios.

Optimization plans, for scenario sets:

- QoS and resource restrictions of the scenarios.
- Available resources for the scenario set.

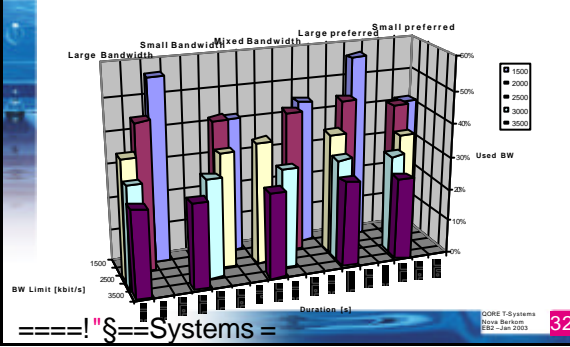
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QORE Optimization using mixed bandwidth algorithm



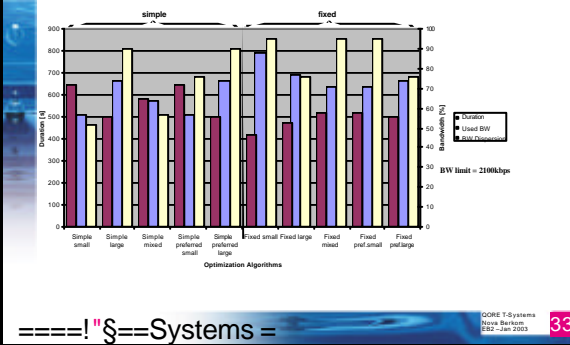
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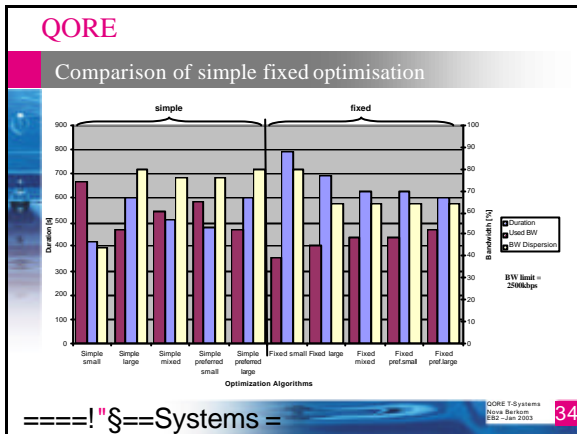
Comparison of Different Optimisation algorithms



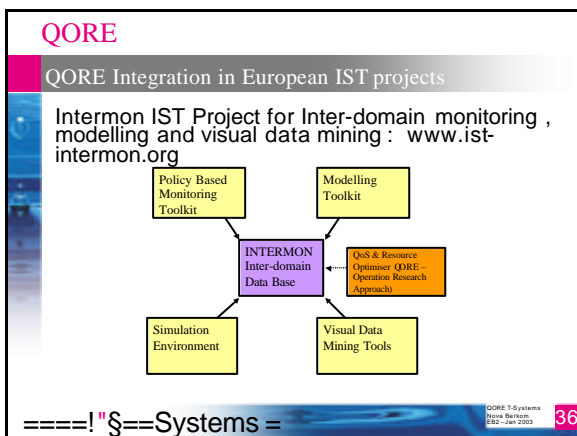
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Comparison of simple/fixed optimization

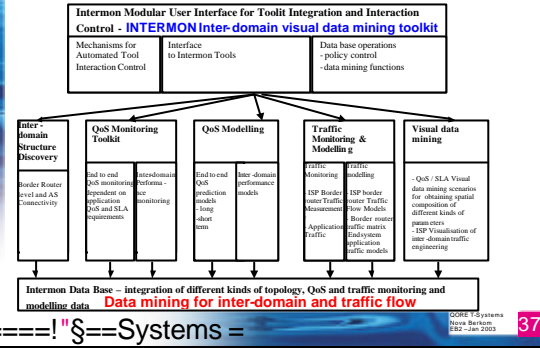




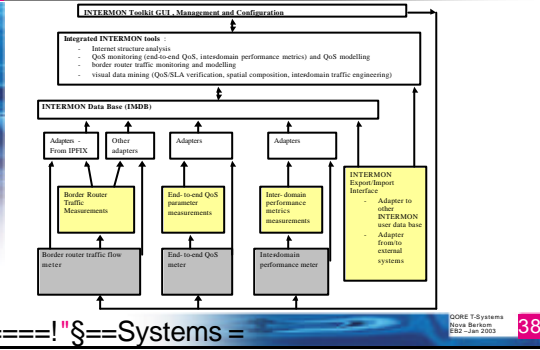
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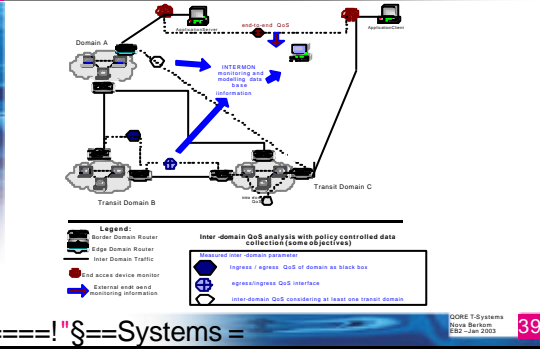
Intermon Structure



Intermon Architecture

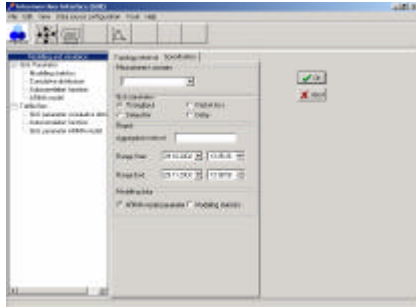


Intermon Test Configuration



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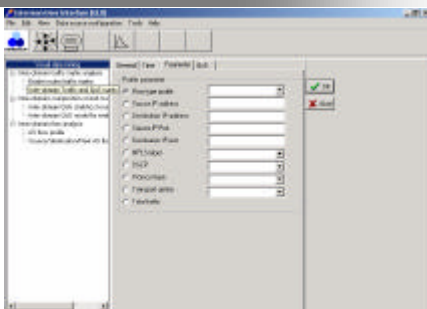
Intermon GUI



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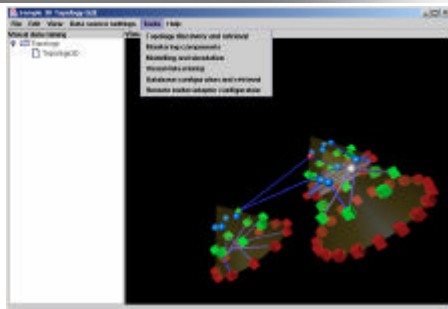
Intermon GUI



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Intermon Visualisation



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Intermon ongoing work

- INTERMON contribution for spatial composition of inter-domain QoS and inter-domain network tomography based on active end-to-end QoS measurement and border router trafficflows
- Data mining based on integrated inter-domain QoS and trafficflow measurement and modelling
- Inter-domain traffic engineering and planning based on border router traffic matrix estimation and inter-domain QoS
- Visual data mining of inter-domain traffic and QoS - automated reporting per aggregation intervals (hour, day, week, year) based on spatial and temporal dependent QoS and trafficflow measurement and modelling data

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Summary

- **QORE System Design and Technology (Patent pending)**
- **Definition of Operation Research Problem for QoS and Resource Optimization in IP Networks (QORE - Problem) (Patent pending)**
- Examination of selected QoS values in Applications
- Identification and Implementation of different Optimization Strategies in dedicated Scenarios
- Test in Lab environment
- Basis Input for Intermon

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Summary

- **Optimal resource modelling for QoS based Virtual Private Networks**
- **Optimisation of resource scheduling for QoS based applications with different time requirements**
- **Optimal delay tolerance**
- **Optimisation of QoS and resource allocation levels of elastic applications**
- **Optimal resource assignment for cost restricted QoS based applications**
- **Flexible resource allocation for QoS support of mobile access networks**

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Summary

Discussions on the future generations mobile communication systems and key technologies in future Internet societies.

- The Social key words in the future generations of mobile communications are:
 - “Cost”, “Security” and “Barrier Free”
- The Technical key words in the future generations of mobile communications are:
 - “communications for high speed vehicles”,
 - “wireless access to broadband Internet” and
 - “IP based seamless roaming among different systems”.

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