


Medienengineering

Netzwerktechnologien mit QoS

Netzwerktechnologien
und multimediale
Teledienste




Universität
Potsdam
Institut für
Informatik

QoS Management in regelbasierten Netzen mit RSVP und DiffServ


Klaus Rebenburg

Mit Materialien aus einem Vortrag von Andreas Kind



Inhalt


Netzwerktechnologien
und multimediale
Teledienste



Universität
Potsdam
Institut für
Informatik


- QoS Management in regelbasierten Netzen mit RSVP und DiffServ
 - Einleitung
 - QoS in IP-Netzen
 - IntServ/RSVP
 - DiffServ
 - Regelbasierte IP-Netze
 - Motivation
 - Komponenten und Protokolle (COPS, LDAP)
 - Beispiele
 - Zusammenfassung

2



Inhalt

Netzwerktechnologien
und multimediale
Teledienste



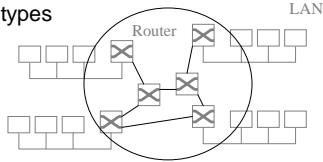
Universität
Potsdam
Institut für
Informatik

- QoS Management in regelbasierten Netzen mit RSVP und DiffServ
 - > IP-Einleitung
 - QoS in IP-Netzen
 - IntServ/RSVP
 - DiffServ
 - Regelbasierte IP-Netze
 - Motivation
 - Komponenten und Protokolle (COPS, LDAP)
 - Beispiele
 - Zusammenfassung

3

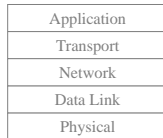


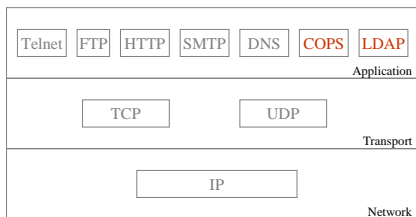
- Connecting computers
 - Resource sharing
 - High reliability
 - Cheaper compared to mainframes
 - Networking people (e.g. email)
- Communication types
 - Broadcast
 - Point-to-point
 - Multicast
- LAN/WAN





- Physical Layer
 - Physical transmission
- Data Link Layer
 - Eliminate physical transmission errors
- Network Layer
 - Routing
- Transport Layer
 - Ensure specific delivery
- Application Layer
 - Various protocols



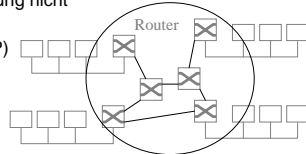




- Transport Control Protocol (TCP)
 - Reliability for end-to-end byte stream over unreliable internetwork
 - Dynamic adaptation to changing network parameters (e.g. congestion control)
 - Connections and ports (e.g. 23 for telnet, 80 for HTTP)
- User Datagram Protocol (UDP)
 - Encapsulated raw IP datagrams
 - Maybe out of order and uncomplete
- Socket Application Programming Interface (API)



- Heutiges Internet basiert auf *best-effort*-Weiterleitung von Paketen
 - Jedes Packet wird gleich behandelt
 - Wenn Router überladen ist, werden Pakete fallengelassen
 - Keine Reservierung
 - Bandbreitenbelegung nicht vorhersehbar
 - Packet Routing (IP) vs. Cell Switching (ATM)





- QoS Management in regelbasierten Netzen mit RSVP und DiffServ
 - Einleitung
 - > QoS in IP-Netzen
 - IntServ/RSVP
 - DiffServ
 - Regelbasierte IP-Netze
 - Motivation
 - Komponenten und Protokolle (COPS, LDAP)
 - Beispiele
 - Zusammenfassung



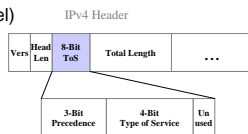
- Service Level Agreement
- Parameters
 - Min/max bandwidth
 - Average bandwidth
 - Min/max delay
 - Delay variation tolerance (jitter)
 - Loss ratio
 - Error ratio
- IP *best effort* forwarding at routers cannot guarantee QoS
 - Bandbreite, *jitter*, Verzögerung, etc. **nicht** vorhersehbar



- Klassifikation von Paketen
 - Verkehrsflüsse
 - Verkehrsklassen
- Differenzierte Weiterleitung in Routern
 - Entsprechend Verkehrsfluss oder -klasse
 - Bandbreite, *jitter*, Verzögerung, etc. vorhersehbar
- Reservierung (hard QoS)
- Priorisierung (soft QoS)
- Alternative: Erhöhung des gesamten möglichen Datendurchsatzes an Routern, so dass auch zu Spitzenzeiten Router nicht überladen sind



- Layer 2
 - MAC Adressen (Quelle/Ziel)
 - Interfaces
- Layer 3
 - IP Adressen (Quelle/Ziel)
 - *Type of Service* (ToS)
 - *Flow label* (IPv6)
- Layer 4
 - UDP/TCP ports
- Layer >4
 - HTTP content type





- Protokolle
 - HTTP, RTP, MPEG, RealAudio, SIP, H.323, ...
- Hardware
 - Processors
 - Net-PC, PDA
 - Mobile Phones
- Anwendungen
 - IP Telephony
 - Telemedizin
 - E-Commerce/Government
 - Digital Libraries
 - Distant Learning



Telephony Model

Closed interfaces

Few long-lived services

64 Kbps

3 minute call, linked to social behaviour

Predictable traffic properties



Internet Model

Open interfaces

Many short-lived services, third party service creation

Mbps to Gbps

Always on

Unpredictable traffic properties



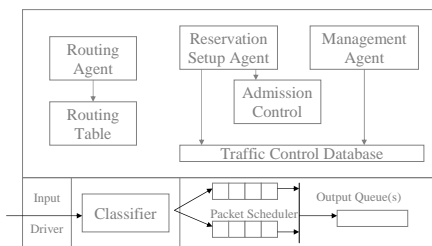
- QoS Management in regelbasierten Netzen mit RSVP und DiffServ
 - Einleitung
 - QoS in IP-Netzen
 - > IntServ/RSVP
 - DiffServ
 - Regelbasierte IP-Netze
 - Motivation
 - Komponenten und Protokolle (COPS, LDAP)
 - Beispiele
 - Zusammenfassung



- Experiments show that packet-based network can in principle support Integrated Services, i.e. the transport of audio, video, real-time and classical data traffic within a single network infrastructure
- Extending the Internet service model
- IETF Working Group (IntServ)
- Requirements
 - Support for QoS control mechanism at nodes
 - Mechanism to communicate QoS information (i.e. RSVP)



- Focus on real-time classes of application traffic
 - Tolerant (e.g. audio/video streaming)
 - Intolerant (e.g. two-way telephony)
- Non real-time classes of application traffic
 - Elastic
 - Interactive burst (e.g. Telnet)
 - Interactive bulk (e.g. FTP)
 - Asynchronous bulk (e.g. SMTP)
- RSVP Service types
 - *Controlled-load* service model for tolerant applications
 - *Guaranteed* service model for intolerant applications





- RSVP is used to communicate QoS requests to all router nodes along transit path of flow
- Temporal (i.e. *soft*) reservation state at router, reservation will be forgotten after a while
- Designed for multicast: Reservations are negotiated for each link
- Applications
 - Support RSVP signalling
- Routers
 - Run RSVP daemon
 - Provide traffic control



- Operation
 - Sender specifies outgoing traffic in RSVP Path message (TSpec)
 - Each RSVP-enabled router on the way to the uni/multicast receiver establishes a soft state including the previous router address
 - Receivers send RSVP Reservation message back to the previous router including a reservation specification (RSpec) and a flow specification (FilterSpec); RSpec specifies the reservation type (controlled/guaranteed); FilterSpec specifies the reservation flow (e.g. addresses, port numbers)
 - RSpec and FilterSpec represent a flow descriptor



- Each router along the upstream path receiving the reservation message uses the admission control process to authenticate the request and allocate the resources.
- An error message is sent back to the receiver if the reservation cannot be satisfied. Otherwise, the reservation request is sent further upstream.
- When the last upstream router (to sender or merge point) accepts the reservation, a confirmation message is sent to the receiver.
- As the traffic arrives at a router, the packets are passed to the classifier. The classifier searches its filtering database to identify the flow.



Resource reSerVation Protocol (RSVP)

Netzwerktechnologien und multimediale Teledienste



- The packet is put into the appropriate queue. Depending on the scheduling algorithm, there may be several queues.
- The scheduler picks a packet from one of the queues and schedules it for transmission over an outgoing link. The scheduler is crucial for enforcing the reserved QoS.

Universität Potsdam Institut für Informatik



Resource reSerVation Protocol (RSVP)

Netzwerktechnologien und multimediale Teledienste



- Parameters for TSpec and RSpec (based on token bucket model)
 - Token rate
 - Token-bucket depth
 - Peak rate
 - Minimum policed size
 - Maximum packet size
- Out of specification traffic is treated best effort

Universität Potsdam Institut für Informatik



Resource reSerVation Protocol (RSVP)

Netzwerktechnologien und multimediale Teledienste



- Policy Data
 - User identification
 - User authentication
 - Credit card billing information
 - Application name

Universität Potsdam Institut für Informatik



- QoS Management in regelbasierten Netzen mit RSVP und DiffServ
 - Einleitung
 - QoS in IP-Netzen
 - IntServ/RSVP
 - > DiffServ
 - Regelbasierte IP-Netze
 - Motivation
 - Komponenten und Protokolle (COPS, LDAP)
 - Beispiele
 - Zusammenfassung



- Simple and coarse method for QoS in IP
- QoS per traffic class; prioritization
- Traffic aggregation
- Extending the Internet service model
- IETF Working Group (DiffServ)
- Requirements
 - Support for QoS control mechanism at nodes
 - Traffic conditioners at network edge



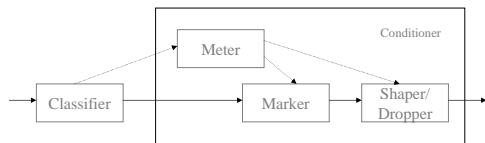
- Small bit-pattern in each packet is used to mark a packet to receive a particular forwarding treatment at each node
 - IPv4: ToS octet
 - IPv6: Traffic Class octet
- } DS Field
- | | |
|---------------|------------|
| 6-Bit
DSCP | 1n
used |
|---------------|------------|
- Code Point (DSCP) is used to select the *per-hop behavior*
 - Expedited Forwarding (EF)
 - Assured Forwarding (AF)



- Expedited Forwarding (EF)
 - One code point
 - Minimal delay and jitter
 - Highest level of aggregate QoS
- Assured Forwarding (AF)
 - 12 code points
 - 3 drop precedences
 - 4 classes



- Traffic conditioners at edge of network
 - Classifying
 - Policing
 - Marking
 - Shaping

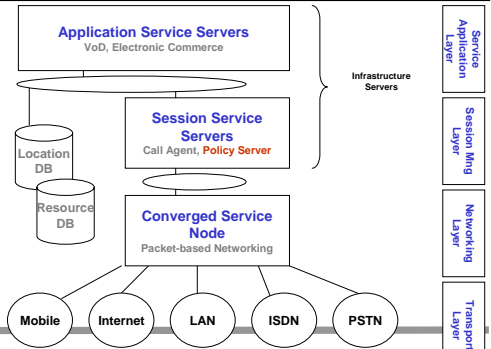




- IntServ
 - Provides resource guarantees per flow
 - Supports signalling for short-lived reservations
 - Soft state doesn't scale with number of flows
 - Duplication of functionality (e.g. classification)
- DiffServ
 - Provides traffic treatment per class of service
 - Centralized admission control that is not designed for short-lived reservations
 - Simpler to implement

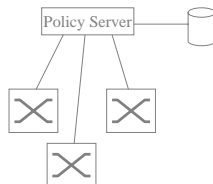


- QoS Management in regelbasierten Netzen mit RSVP und DiffServ
 - Einleitung
 - QoS in IP-Netzen
 - IntServ/RSVP
 - DiffServ
 - > **Regelbasierte IP-Netze**
 - Motivation
 - Komponenten und Protokolle (COPS, LDAP)
 - Beispiele
- Zusammenfassung





- Merging traditional voice and data services onto a unified packet-based network
- Integrated services information infrastructure
- Goal: reduce cost for OAM&P
- Requirements
 - Mobility
 - Security
 - Multicast
 - Openness
 - Scalability
 - QoS

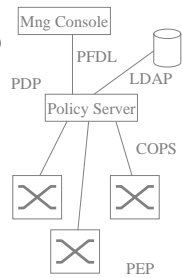




- Demand for consistent translation of service/business level objectives into network element configurations (typically related to QoS and security)
- Device and vendor independent
- Example: Revenue-generating traffic should be forwarded with guaranteed QoS
- Limitation of individual device management
 - No consistent policy enforcement
 - No scalability



- Components
 - Policy Enforcement Point (PEP)
 - Policy Decision Point (PDP)
 - Directory
 - Management console
- Protocols
 - Policy Definition Language (PFDL)
 - Lightweight Directory Access Protocol (LDAP)
 - Common Open Policy Service (COPS)





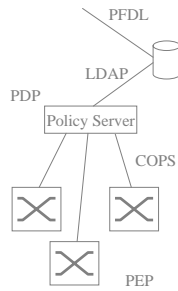
- Verwaltung wesentlicher Netzwerkinformationen
 - Service profiles
 - Media profiles
 - Device profiles
 - Application profiles
 - User profiles
 - Policy rules
- LDAP: Lightweight Directory Access Protocol
 - Simple X.500 (ITU)
 - Zugriffsprotokoll auf hierarchischen Datenbestand



COPS Messages



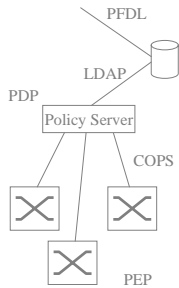
- Initialization (OPN, CAT, CC)
- Request (REQ, DRQ)
 - E.g. RSVP Resv/Path
- Decision (DEC)
- Reporting (RPT)
 - E.g. start billing, monitoring
- Synchronization (SSQ, SSC, KA)



COPS Operation



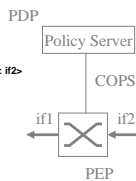
- PEP send OPN (open) to PDP; PDP replies with CAT (client accept) if client type is supported
- Event at PEP; REQ (request) is sent to PDP; PDP replies with DEC (decision) and remembers DEC with handle




COPS Usage for RSVP



- REQ:**
- Handle: a>
 - Context: in&out, path> <In-Interface: if2> <Out-Interface: if1>
 - Client-SI: RSVP path objects
- DEC:**
- Handle: a>
 - Context: in&out, path> <Decision: cmd, install>
- REQ:**
- Handle: b>
 - Context: in&alloc&out, resv> <In-Interface: if1> <Out-Interface: if2>
 - Client-SI: RSVP resv objects
- DEC:**
- Handle: b>
 - Context: in, resv> <Decision: cmd, install>
 - Context: alloc, resv> <Decision: cmd, install>
 - Context: out, resv> <Decision: cmd, install>
 - Decision: replacement, policy-data1>
- RPT:**
- Handle: b>
 - Report: commit>




Netzwerktechnologien und multimediale Teledienste

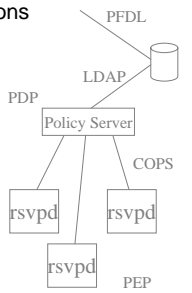
COPS für RSVP

- Admission of RSVP reservations

```


IF APPL EQ "vic" AND
RSVP_IS_BANDWIDTH GE 300
THEN
DENY

IF APPL EQ "vic" AND
RSVP_IS_BANDWIDTH GE 10
THEN
DENY
    
```

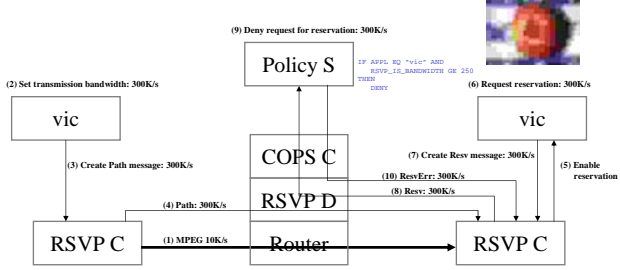


Universität Potsdam
Institut für Informatik

40



Netzwerktechnologien und multimediale Teledienste

Beispiel: Ablehnen von RSVP Reservierung

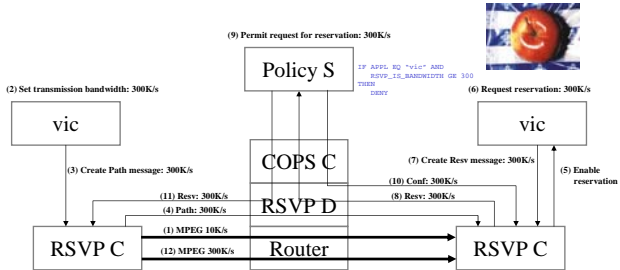


Universität Potsdam
Institut für Informatik

41


Netzwerktechnologien und multimediale Teledienste

Beispiel: Erlauben von RSVP Reservierung



Universität Potsdam
Institut für Informatik

42



- Policy rules for packet classification at edge of network
 - Traffic aggregation
 - Traffic admission
 - Traffic shaping

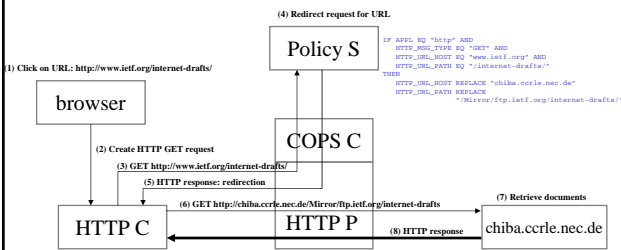


- Umlenkung von HTTP Anfragen

```
IF APPL EQ "http" AND
HTTP_MSG_TYPE EQ "GET" AND
HTTP_URL_HOST EQ "www.ietf.org" AND
HTTP_URL_PATH EQ "/internet-drafts/"
THEN
HTTP_URL_HOST REPLACE "chiba.ccrle.nec.de"
HTTP_URL_PATH REPLACE
"/Mirror/ftp.ietf.org/internet-drafts/"
```

- Filtern von HTTP Anfragen

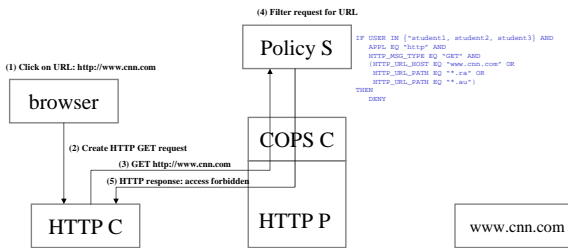
```
IF USER IN {"student1, student2, student3"} AND
APPL EQ "http" AND
HTTP_MSG_TYPE EQ "GET" AND
(HTTP_URL_HOST EQ "www.cnn.com" OR
HTTP_URL_PATH EQ "*.ra" OR
HTTP_URL_PATH EQ "*.au")
THEN
DENY
```



```
IF APPL EQ "http" AND
HTTP_MSG_TYPE EQ "GET" AND
HTTP_URL_HOST EQ "www.ietf.org" AND
HTTP_URL_PATH EQ "/internet-drafts/"
THEN
HTTP_URL_HOST REPLACE "chiba.ccrle.nec.de"
HTTP_URL_PATH REPLACE
"/Mirror/ftp.ietf.org/internet-drafts/"
```

Beispiel: Filtern von HTTP Anfragen

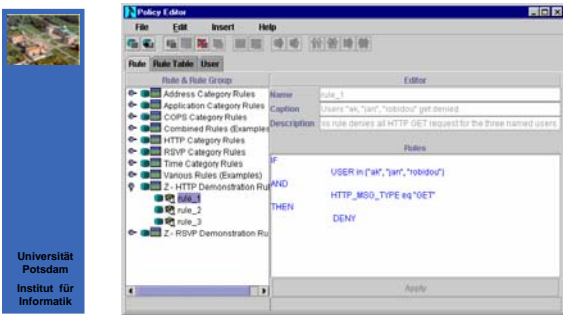
Netzwerktechnologien und multimediale Teledienste



46

Beispiel: Policy Editor (NEC)

Netzwerktechnologien und multimediale Teledienste




47

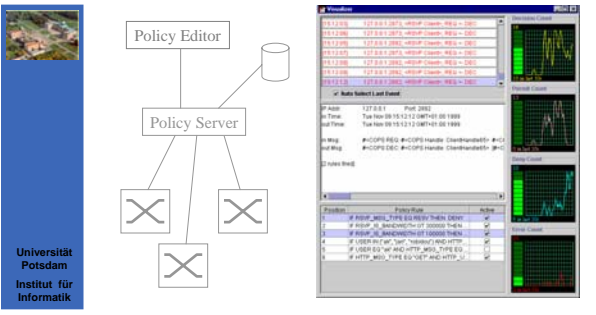
Beispiel: Policy Editor (NEC)

Netzwerktechnologien und multimediale Teledienste




48


Beispiel: Policy Visualizer (NEC)
Netzwerktechnologien und multimediale Teledienste




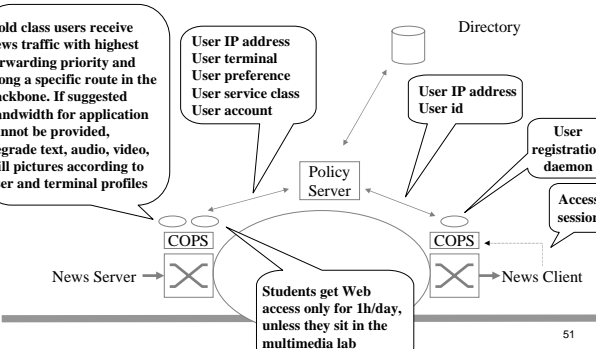
49


Offene Probleme regelbasierter Netze
Netzwerktechnologien und multimediale Teledienste

- Flexibilität
 - Fest Semantik für Konditionen und Aktionen (z.B. COPS client types)
 - Passiver Regelauslösemechanismus
 - Deklarative, d.h. nicht-prozedurale Regeln
- Zentralisierung
 - Keine funktionale Verteilung (falls nötig)
 - Policy Server Belastung
 - Performanz- und Skalierbarkeitsprobleme
- Widersprechende Regeln
 - Erkennung
 - Konfliktlösung

50


Szenarios
Netzwerktechnologien und multimediale Teledienste



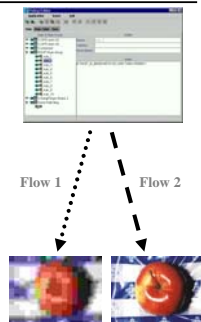
51



- QoS Management in regelbasierten Netzen mit RSVP und DiffServ
 - Einleitung
 - QoS in IP-Netzen
 - IntServ/RSVP
 - DiffServ
 - Regelbasierte IP-Netze
 - Motivation
 - Komponenten und Protokolle (COPS, LDAP)
 - Beispiele
- > Zusammenfassung



- Policies can help to regulate multimedia traffic
 - Specific flows can be treated according to specific policies
- Policy Framework supports simple translation of service/business level objectives into network element configurations
- COPS client types: RSVP, DiffServ





- B. Davie et al: Switching in IP Networks, Morgan Kaufmann, 1998
- J. Mambretti and A. Schmidt: Next Generation Internet, Wiley 1999
- D. P. Black: Building Switched Networks, Addison Wesley, 1999
- P. Ferguson and G. Huston, Quality of Service: Delivering QoS on the Internet and in Corporate Networks, Wiley, 1998
- J. Strassner, Terminology for Describing Network Policy and Services, draft-strassner-policy-terms-00.txt, IETF, August, 1998
- M. Decina and V. Trecordi, Convergence of Telecommunications and Computing to Networking Models for Integrated Services and Applications, Proceedings of the IEEE, 85(12), pp. 1887-1913, December 1997
- D. Durham and R. Yavatkar: Inside the Internet's Resource reSerVation Protocol, Wiley, 1999



URLs



- COPS: <http://www.ietf.org/html.charters/rap-charter.html>
- DEN: <http://murchiso.com/den/>
- DiffServ: <http://www.ietf.org/html.charters/diffserv-charter.html>
- IntServ: <http://www.ietf.org/html.charters/intserv-charter.html>
- LDAP: <http://www.ietf.org/html.charters/ldapext-charter.html>
- Policies: <http://www.ietf.org/html.charters/policy-charter.html>
- RSVP: <http://www.ietf.org/html.charters/rsvp-charter.html>



Abkürzungen



- COPS: Common Open Policy System
- DiffServ: Differentiated Services Framework
- IETF: Internet Engineering Task Force
- IntServ: Integrated Services Framework
- ITU: International Telecommunication Union
- LAN: Local Area Network
- LDAP: Lightweight Directory Access Protocol
- OAM&P: Operation, Administration, Management and Provisioning
- PDP: Policy Decision Point
- PEP: Policy Enforcement Point
- PFDL: Policy Framework Definition Language
- QoS: Quality of Service



Abkürzungen



- RSVP: Resouce reSerVation Protocol
- TCP: Transport Control Protocol
- UDP: User Datagram Protocol
- WAN: Wide Area Network
