# Self-Management of Cognitive Future InterNET Elements

Self-NET

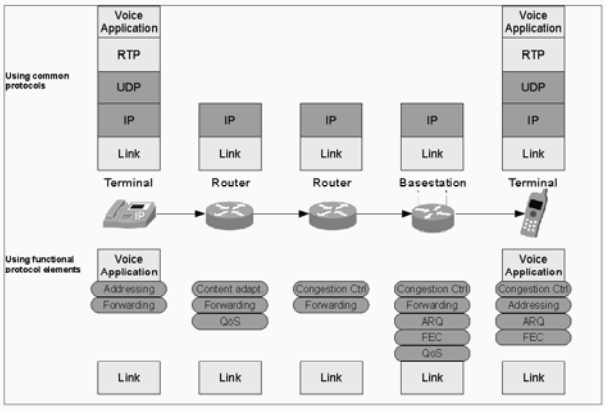
Fraunhofer FOKUS Institute for Open Communication Systems 1988 – 2008

## Functional Protocol Elements

Replacing current transport and network protocols by functional protocol elements (FPE). FPEs are elements which implements features like Automatic Repeat Query (ARQ), Congestion Control, Forward Error Correction (FEC) or QoS-Features. This Elements can be assembled to a user-defined combination to fit to the needs.

**Current situation**

- Strict differentiation between datagram and stream based protocols
- UDP and TCP do not fit to applications like VoIP, IPTV, Online Gaming
- TCP can cause a high delay for retransmitted packets
- Accidentally dropped TCP packets can decrease the used bandwidth dramatically, especially in ad-hoc and mesh networks
- The mass usage of UDP can block links because of missing congestion contro

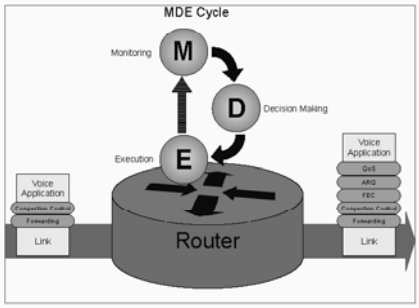



**New possibilities by using FPE**

- All needed features can be assembled to an individual fitting protocol
- The strict differentiation between datagrams and stream is not necessary any more
- Congestion control can be added to UDP-like traffic to avoid overloaded links and so caused packet dropping
- If the needs for the application, link, or network change the composition can be modified dynamically
- Network elements can add or remove FPEs if this can increase the quality
- FPEs can be added for single hop, e.g. ARQ at wireless links can reduce jitter

## Optimising with M-D-E Cognitive Cycle

If the current situation of the network and the demands of the stream is always known the router can continuously decides how to fulfil the requirements of the streams. If the software is able to learn by experience, the optimisation will fit well to the router's situation.




**Monitoring**

- Current QoS parameters (delay, jitter, packet loss)
- Which type of content the router passes (Video, Voice, FTP, etc.)
- Additional informations like flags (e. g. DSCP or special FPE) set by sender or another network element

**Decision making**

- Uses the monitoring results as main input
- Decides whether a modification is necessary or not
- Prioritizes streams or data types
- Adding or removing extra abilities like link based ARQ, FEC or any other FPE **Execution**
- Enforce the decisions made by the decision making part
- Makes use of the dynamic protocol composition to change the protocol composition during transportation
- Re-routes streams to another direction if the current route is overloaded

**M-D-E layer**

- It is envisioned to support hierarchical M-D-E layers to boost the optimisation potential.

**Network Elements**

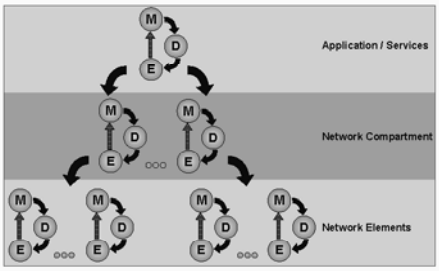
- M-D-E layer to work in network elements like routers, access points or user terminals

**Network Compartment**

- M-D-E layer to manage a whole network or network part
- Initiates re-routing, load balancing etc.

**Application / Services**

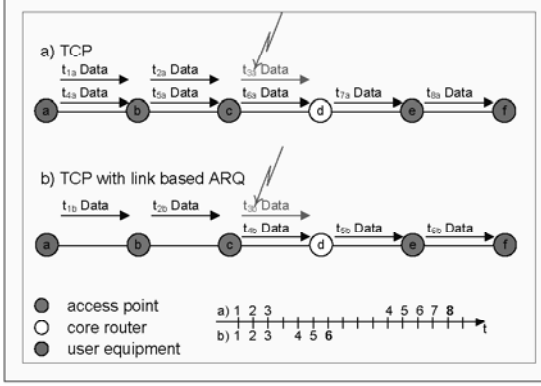
- M-D-E layer to influence the optimisation by provided services like IMS, e.g. to enforce end-to-end QoS




## Scenarios

**Link based ARQ**

- TCP can cause high delay for retransmitted packets
- Often only one link causes nearly 100% of lost packets
- Adding ARQ for this link will reduce jitter much
- FPEs can be added for single hop, e.g. ARQ at wireless links can reduce jitter




- Router d drops several packets because of transmission errors
- Example a) shows the duration $t_{8a}$ until the retransmitted packet reaches the destination
- Example b) shows how the duration is shortened to $t_{6b}$ if a link based ARQ is used

**Congestion Control**

- The increasing use of UDP based real time applications like VoIP or videostreaming causes problems in fully loaded networks
- TCP connections are decreasing there bandwidth by reducing their window size if packets got lost because of an overload
- Applications using UDP usually do not care about the network load, they continue sending high data rates although the TCP traffic will be displaced
- Using congestion control with datagram based applications can avoid these problems, e.g. a video streaming application can reduce the needed bandwidth by adjusting the transmitted video quality (resolution, colours, codec, etc.)

Re-Routing / Forwarding

- Videostreaming like IPTV and Video on demand needs an almost constant bandwidth because packets must reach the receiver in time. It is not always possible to throttle the needed bandwidth.
- Re-routing the stream to another way to the destination can increase the quality if the current link is overloaded
- The decision how to forward the stream is done by the internal network element M-D-E cycle supported by the higher layered network compartments M-D-E entity.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SEVENTH FRAMEWORK PROGRAMME