# Critical Review of all RPR MAC Proposals

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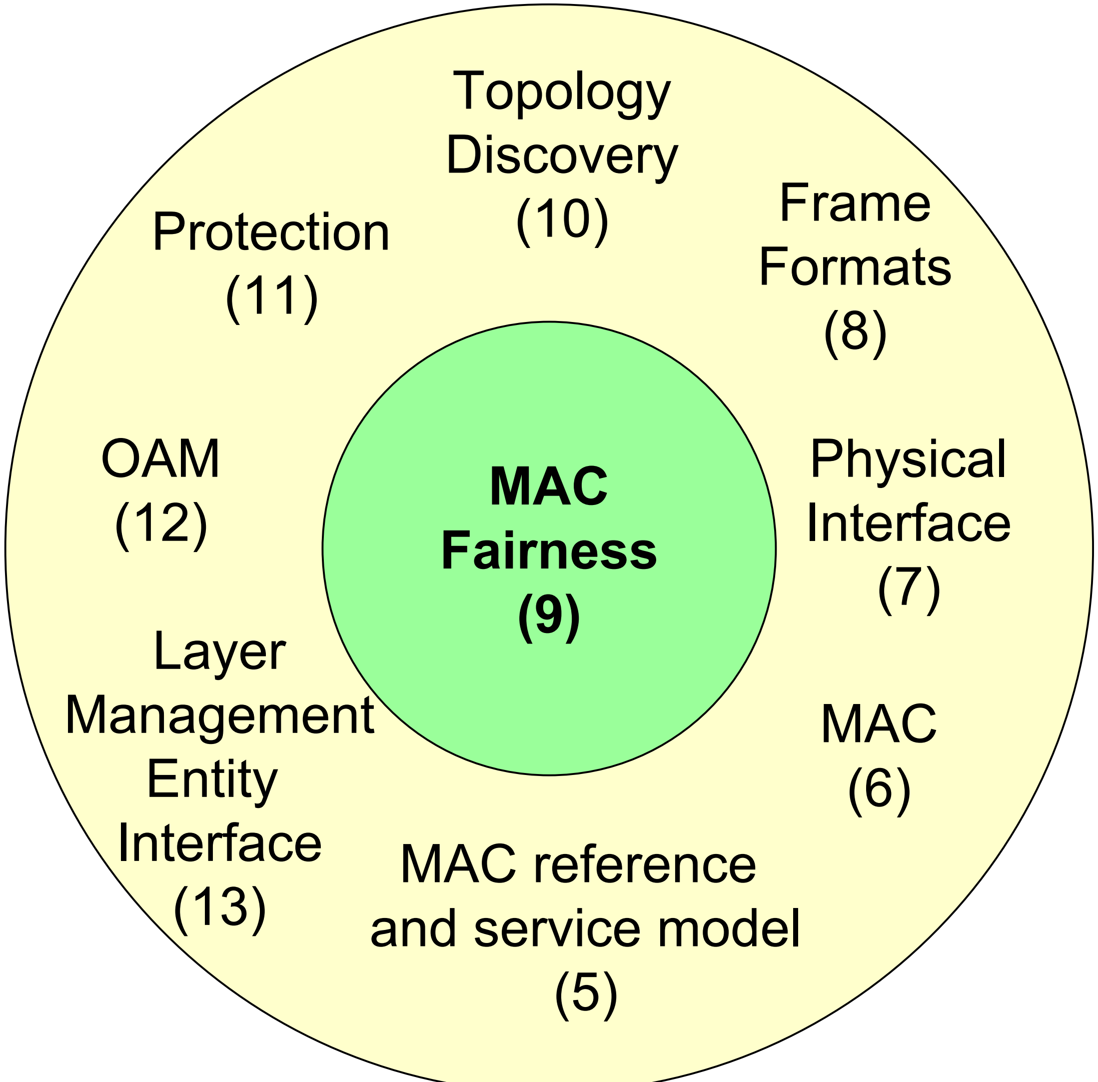
# RPR MAC Design Goals

- Plug and play
- Link fairness
- SLA support
- High performance

- Optimal performance for 64 stations (128 stations reduced performance)
- Bit rates from 155 Mbit/s up to 10 Gbit/s (and higher)
- Up to 1000 km ringlets
- Single (fault), dual, and multiple ringlets

# Central Position of MAC Fairness Control




**Chapter 9** will still need major performance studies and intensive debates before text can be included into the draft

# RPR MAC Proposals

**Gandalf** (Cisco, Corrigent Systems, Jedai Broadband Networks)

**Darwin** (Cisco, Nortel)

**Alladin** (Alcatel, Dynarc, Lantern, Luminous, NEC, Nortel, Vitesse)

**DVJ** (Cypress Semiconductor, University of Oslo)

**IKN** (Vienna University of Technology)

# Required MAC Protocol Properties

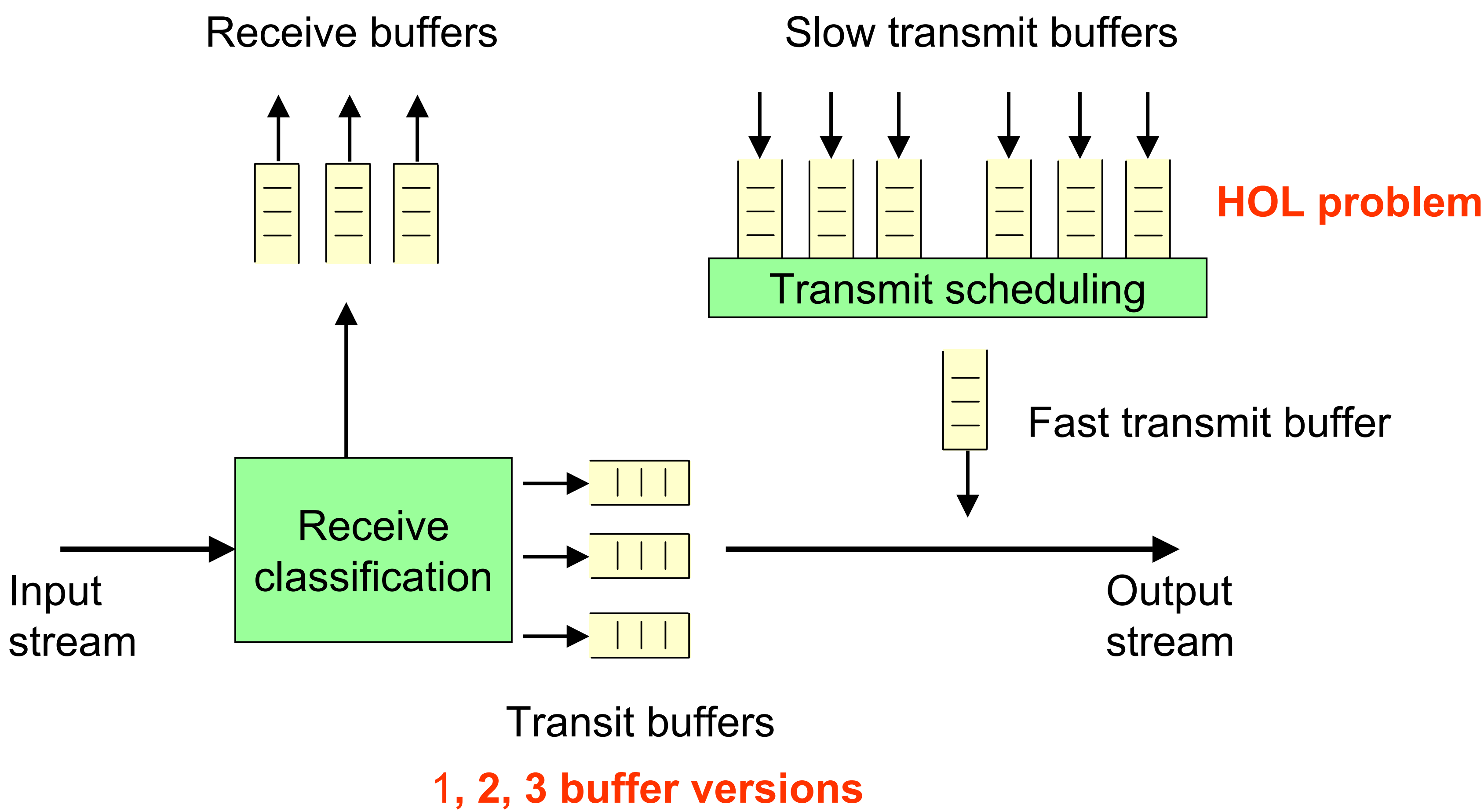
**Support of:**

- Link-fairness
- Service Level Agreements (SLAs)
- Heterogeneous link speeds

**Performance properties:**

- Control of flow-based source-destination traffic
- No HOL blocking
- Very high network throughput
- Low delays / controlled delays
- No packet losses
- No backpressure
- Transit buffer size at most one or two MTUs
- Bottleneck-link fairness based on source-destination flows
- Adaptivity to traffic dynamics

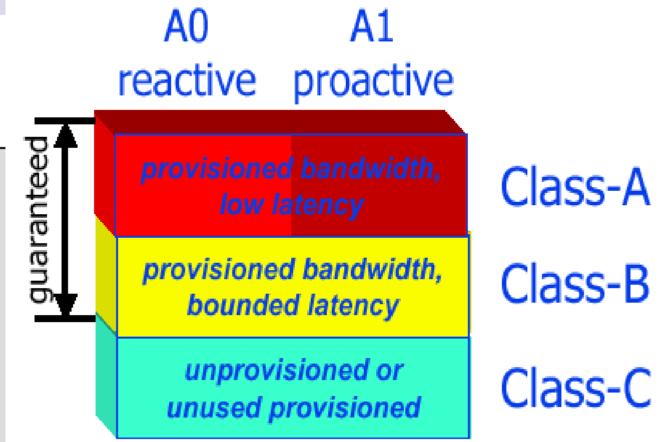
# Basic Structure of Stations



# Support of Three Priorities

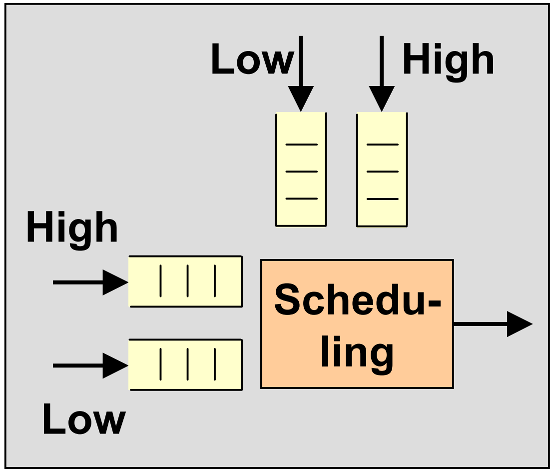
**Gandalf / Darwin**

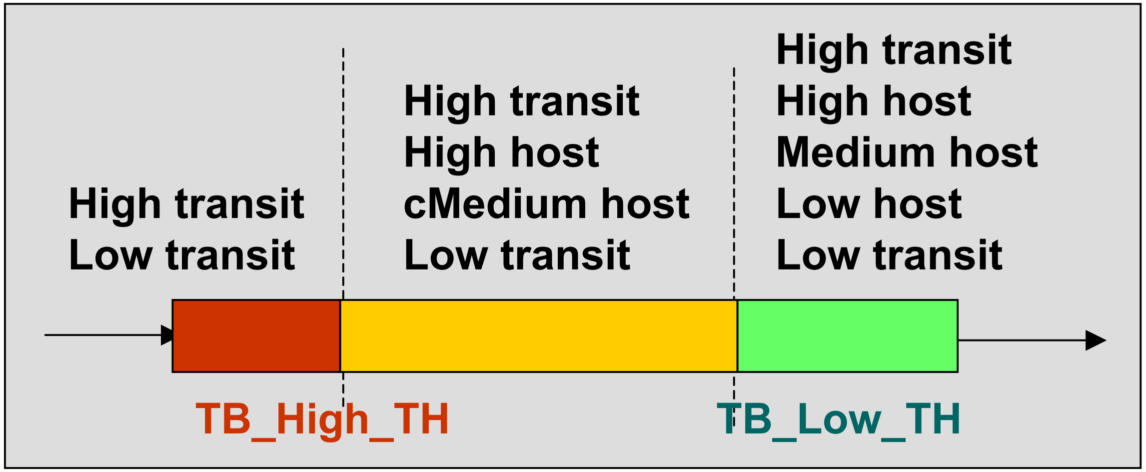
**DVJ**




- **High Priority**
  - Guaranteed bandwidth (provisioned)
  - Bounded delay and bounded jitter
- **Medium Priority**
  - Committed Access Rate (CAR) for MP (cMP)
  - MP Traffic exceeding CAR (eMP) is subject to fairness algorithm control
  - Committed bandwidth (provisioned), best effort for excess traffic
  - Bounded delay and (loosely) bounded jitter
- **Low Priority**
  - No guarantees
  - Best effort for bandwidth, delay and jitter

# Gandalf / Darwin



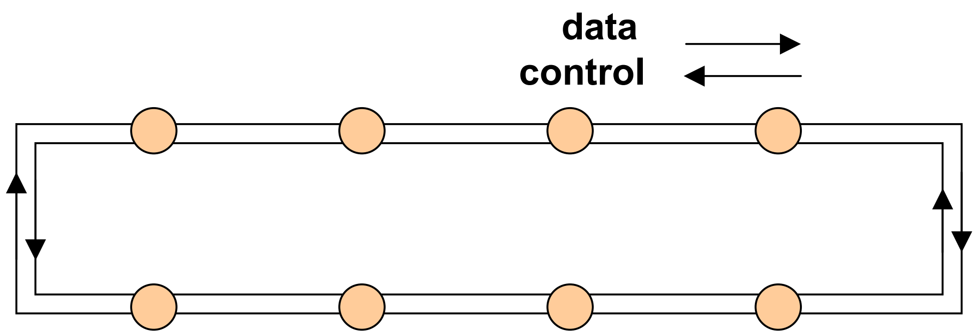




Transit buffer (low priority)

**Operation principles :**

- Local scheduling between transmit and transit buffers (high and low)
- Backpressure control on threshold passing in  transit buffer
- Informed sources reduce their rates accordingly

# Alladin

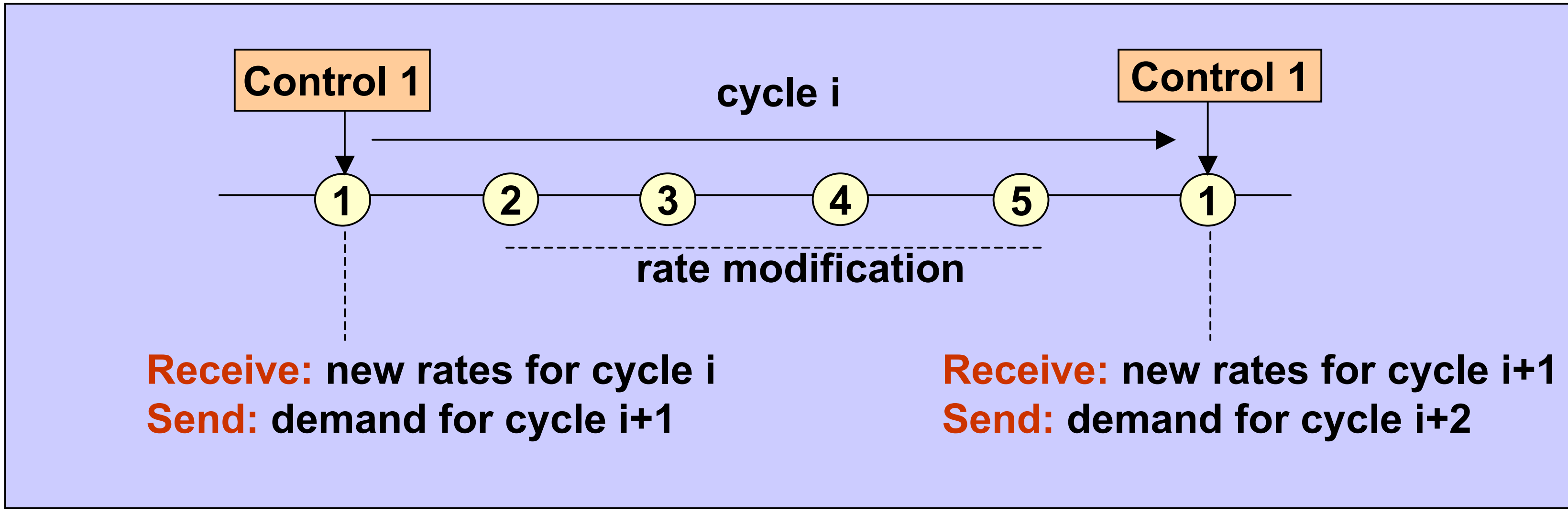



- Measurement driven
- Bottleneck station-flow fairness

**Operation principles :**

- Each station monitors its output link to measure rates of each source flow
- Periodically, each station calculates a RCF (Rate Control Factor) for its link which is sent upstream to all stations
- Upon arrival of a control packet, the allowed rate for that link is reduced

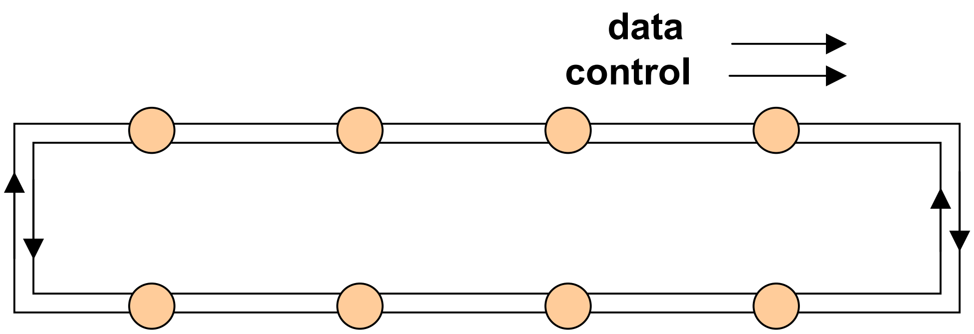
# DVJ




**Operation principles :**

- Control packet with traffic demand circulates for each station
- All other stations modify flow rates in control packet according to bottlenecks
- Upon return, the issuing station obtains the allowed rate for each link

# IKN




- Bottleneck flow-fairness
- Demand driven
- Greedy and scheduled access
- Data and control on each ringlet in the same direction
- No backpressure control

**Operation principles :**

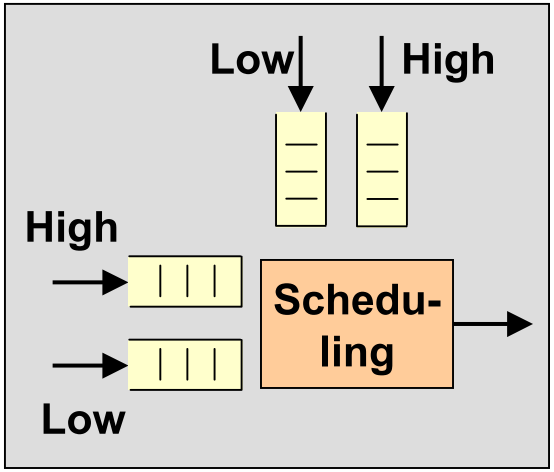
- Traffic demand is cyclically advertised to all stations
- All stations locally schedule their traffic volume within current fairness cycle

- Bottleneck flow-fairness per fairness cycle
- Access is greedy for underutilized links, it is scheduled for bottleneck links

# Performance Evaluations of RPR MACs

- Up to now only a few performance studies gave useful results
- Complex source models disguise important properties of a MAC
- TCP cannot be used to evaluate a MAC, instead its influence of a MAC of the behavior of TCP connects is important
- Well-understood sources and traffic scenarios are required for MAC evaluations
- Many scenarios are still needed to find weaknesses or to proof robustness against traffic and system parameters
- Web-posted precompiled OPNET scenarios are unfortunately only of limited use
- IKN designed automatic performance evaluation of test scenarios

# MAC Transmission Path




- Connection between two stations to be considered as a flexible and dynamic point-to-point link:
    - no packet losses on the medium
    - keep the transit path clean
    - no or only controlled scheduling

- Transit buffers only to be used
    - to avoid packet collisions
    - time-controlled insertion of real-time packets of provisioned traffic

# Evaluation Issues

1. Simplicity
2. Operability
3. Testability
4. Extendibility
5. Scalability
6. Traffic dynamics
7. Robustness
8. Behavior
9. Fairness performance (flow or node)
10. Throughput performance
11. Delay performance
12. Capabilities (SLAs, heterogeneous links)

# Conclusions

- The MAC is the heart of the IEEE 802.17 Standard
- MACs are very difficult to design and even more to evaluate
- Evaluations are not yet at the state for proper selection
- Many simulations still have to be done before any conscious decision can be made
- Finding of any weaknesses or proofing robustness must be done now, fixes are impropriate and reduces confidence in the standard

**MAC performance significantly impacts success story of IEEE 802.17**

# Critical Review of all RPR MAC Proposals

**Back-up Foils**

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# Purpose of these Back-up Foils

This evaluation is still incomplete or might not completely right

The comparison is put together as a basis for discussion in the
MAC fairness subgroup during the St. Louis meeting, March 11-14, 2002

# (1) Simplicity

**Protocol simplicity is mainly given by**
- number of control packets
- number of parameters
- number of communication types and processes
- procedure of the communication process

**Gandalf:** - many parameters and constants
**Darwin** - threshold procedure is rather complex

**DVJ:** ?

**Alladin:** - cyclic bottleneck fairness advertisement
- local fairness scheduling

**IKN:** - cyclic demand advertisement
- single control packet
- local bottleneck fairness scheduling

# (2) Operability

**Protocol operability is mainly given by**
- number parameters to be set
- dependency of traffic and configuration parameters
- degree of adaptivity
- required skills for operation (plug and play)

**Gandalf:**
**Darwin**
- many parameters to be set,
- only heuristic knowledge about parameter setting
- strong relationship between parameters and traffic pattern

**DVJ:** -?

**Alladin:** - few parameters

**IKN:** -few parameters, easy to make them adaptive

# (3) Testability

**Protocol testability is mainly given by**
- number of control packets
- number of parameters
- number of communication types and processes
- procedure of the communication process
- behavior model (predictable, stochastic, deterministic)

**Gandalf:** - difficult (many parameters, stochastic behavior, etc.)
**Darwin** - how to test proper setting of parameters in all stations?
- how to test behavior

**DVJ:** - ?

**Alladin:** - ?

**IKN:** - easy (deterministic scheduling, no local properties)

# (4) Extendibility

**Protocol extendibility is mainly given by**
- possibility to include new features
- possibility to cover other topologies (short-cut links, ring-mesh)
- possibility to cover new technologies like WDM

| | |
|---|---|
| **Gandalf:** **Darwin** | - possible |
| **DVJ:** | - possible |
| **Alladin:** | - possible |
| **IKN:** | - possible (including WDM medium scheduling) |

# (5) Scalability

**Protocol scalability is mainly given by**
- extendibility to ring length, link speeds, node number

**Gandalf:**
**Darwin**

- proper threshold setting required
- more ?

**DVJ:**

- probably

**Alladin:**

- probably

**IKN:**

- more control packets to split up demand information

# (6) Traffic Dynamics

**Protocol traffic dynamics is mainly given by**
- performance insensitivity to slow or fast traffic dynamics

| | |
|---|---|
| **Gandalf: Darwin** | - fast changes ? |
| **DVJ:** | - ? |
| **Alladin:** | - fast changes ? (measurement driven) |
| **IKN:** | - highly adaptive fast changes (demand advertisement) |

# (7) Robustness

**Protocol robustness is mainly given by**
- number of control packets
- number of parameters
- number of parameters
- number of communication types and processes
- procedure of the communication process
- ability to handle failures

**Gandalf: Darwin** - many control packets

**DVJ:** - many control packets

**Alladin:** - many control packets

**IKN:** - one single control packet

# (8) Behavior

**Protocol behavior is mainly given by**
- degree of predictability
- degree of intrinsic stochastic
- degree of deterministic

**Gandalf: Darwin** - stochastic (high transit buffer occupancy for high throughput)

**DVJ:** - rather predictable (demand-driven)

**Alladin:** - rather predictable but also stochastic (measurement-driven)

**IKN:** - predictable and close to deterministic (demand-driven, scheduling)

# (9) Fairness Performance

**Protocol fairness is mainly given by**
- capability to assure controlled and fair access to medium

global fairness (80`s)➔ link fairness per station ➔ link fairness per station pair

**Gandalf:** - link bottleneck fairness based on source flows
**Darwin** - degree of fairness open

**DVJ:** - link bottleneck fairness based on source flows
- fairness ?

**Alladin:** - link bottleneck fairness based on source flows
- degree of fairness to be discussed

**IKN:** - link bottleneck fairness based on source-destination flows
(return to source flow fairness easy)
- theoretical fairness approached

# (10) Throughput Performance

**Throughput performance is mainly given by**
- ability to exploit spatial reuse while preserving throughput fairness

**Further studies required**

**Gandalf: Darwin** - high but suboptimal throughput

**DVJ:** - ?

**Alladin:** - high but suboptimal throughput

**IKN:** - highest network throughput of all MAC proposals, while preserving source-destination flow fairness
- theoretically fair throughput flows approached

# (11) Delay Performance

**Delay performance is mainly given by**
- access scheme
- occupancy of intermediate transit buffer

**Further studies required**

**Gandalf:** - transmit buffers may strongly transfer time on medium

**Darwin**

**DVJ:** - ?

**Alladin:** - low

**IKN:** - low

# (12) Capabilities

**Required capabilities**
- heterogeneous link speeds
- support of SLAs
- support of high-degree quality circuit emulation

**Heterogeneous link speeds**
- possible when knowledge of link utilization
  Gandalf/Darwin, probably yes, DVJ ?, Alladin yes, IKN yes

**Support of SLAs**
- with source link fairness doubtful for all cases
- with source-destination link fairness: IKN yes

**support of high-degree quality of circuit emulation**
- Gandalf/Darwin, DVJ, Alladin ??
- with deterministic scheduling and time-controlled transmissions : IKN yes

# RPR MAC Comparison

| | Gandalf | Darwin | Alladin | DVJ | IKN |
|---|---|---|---|---|---|
| 1) simplicity | | | | | |
| 2) operability | | | | | |
| 3) testability | | | | | |
| 4) extendibility | | | | | |
| 5) scalability | | | | | |
| 6) traffic dynamics | | | | | |
| 7) robustness | | | | | |
| 8) behavior | | | | | |
| 9) fairness | | | | | |
| 10) throughput | | | | | |
| 11) delay | | | | | |
| 12) capabilities | | | | | |