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IP-over-ATM: Migrations, Adaptation Problems and Solutions

ACTS

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Content

- Introduction of the European ACTS project EIES (European Information Exchange Service)
- IP-over-ATM difficulty
- IP-over-ATM possibilities: Classical IP, LAN Emulation (LANE), and MPOA
- IP effectiveness: protocol overhead, TCP throughput obstacles, sender and receiver buffers, RTT and MTU deadlocks, UDP and Client performance
- Performance Improvements and further developments

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The ACTS project EIES

- Definition, implementation, and experimentation of advanced telecommunication services
- Support routine and non-routine communication between different maritime players
- Define and transpose the user requirements for the service development of EIES
- Build-up a pre-commercial global EIES service
- Establish an ATM link between the different harbour sites (Bordeaux, Bremen, Brest, Santander) to use the prototypes in real life

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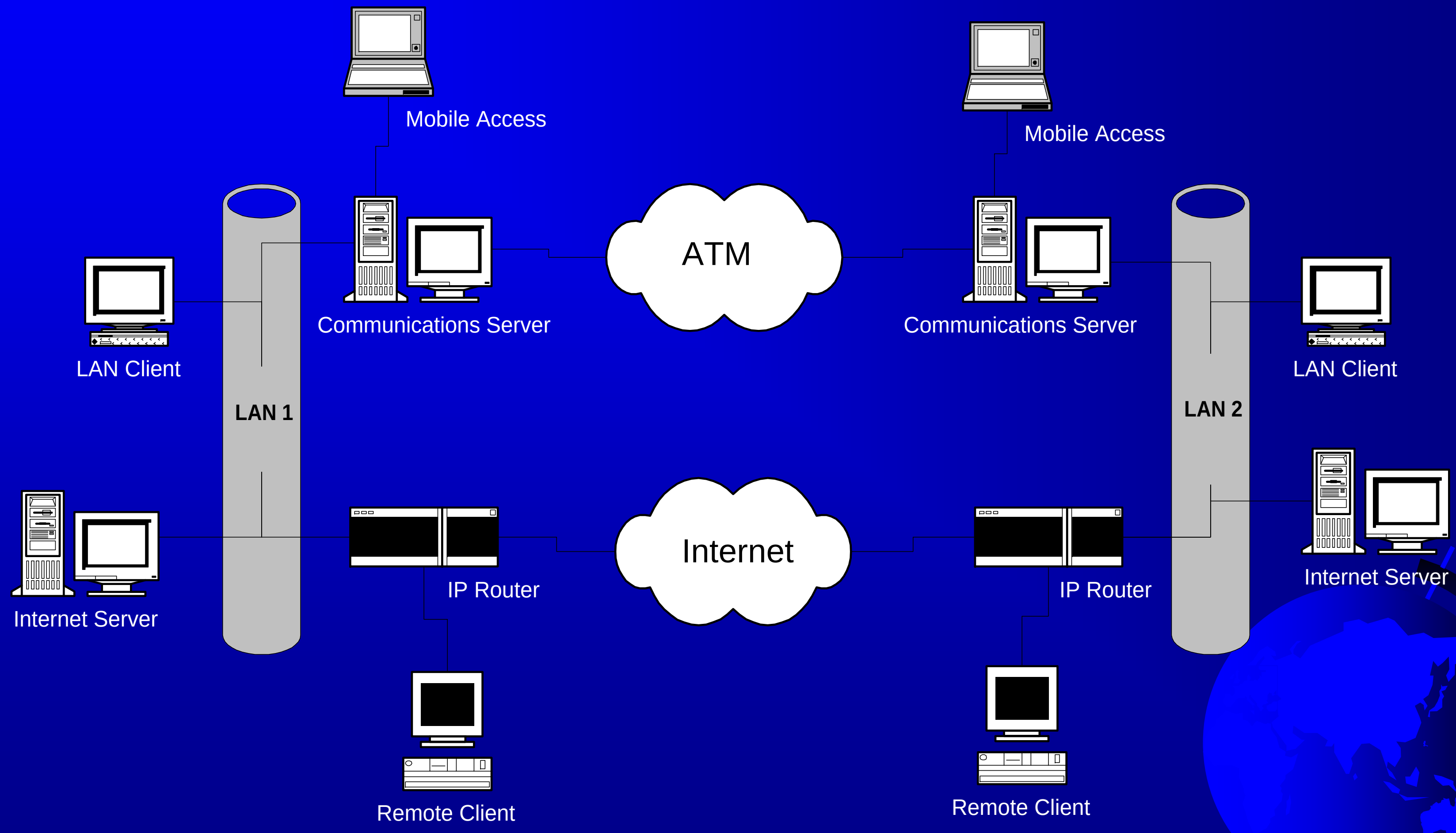
EIES services

- Computer Supported Cooperative Work (CSCW)
- Distribution of multimedia information about different databases (BluePages and Port Entry Guide)
- Integration of Electronic Data Interchange (EDI) and Electronic Mail (Email)
- Mobile communication (DSRR, DECT, and Inmarsat) for the mobile access to the services.
- Fixed networks: ATM, ISDN, and Internet (IP)

EIES platform



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IP features

- Internet Protocol works connectionless (hop-by-hop-transmission)
- No acknowledgements, error- and duplicate detection with IP
- Data packets are variable: 20 byte - 65 kbyte; destination address identified the other client
- Lost data packets have to repeat requested by higher layer protocols (TCP)
- Multicast/broadcast functions
- Best-Effort: Type-of-Service (TOS)

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ATM features

- Connection-oriented technologie: virtual connections will establish for the cell transport (PVC/SVC)
- ATM has its own address structur, signaling, and routing funktions
- 53 byte cells with fixed size contain payload and control data
- Point-to-point connections
- Quality-of-Service (QoS)

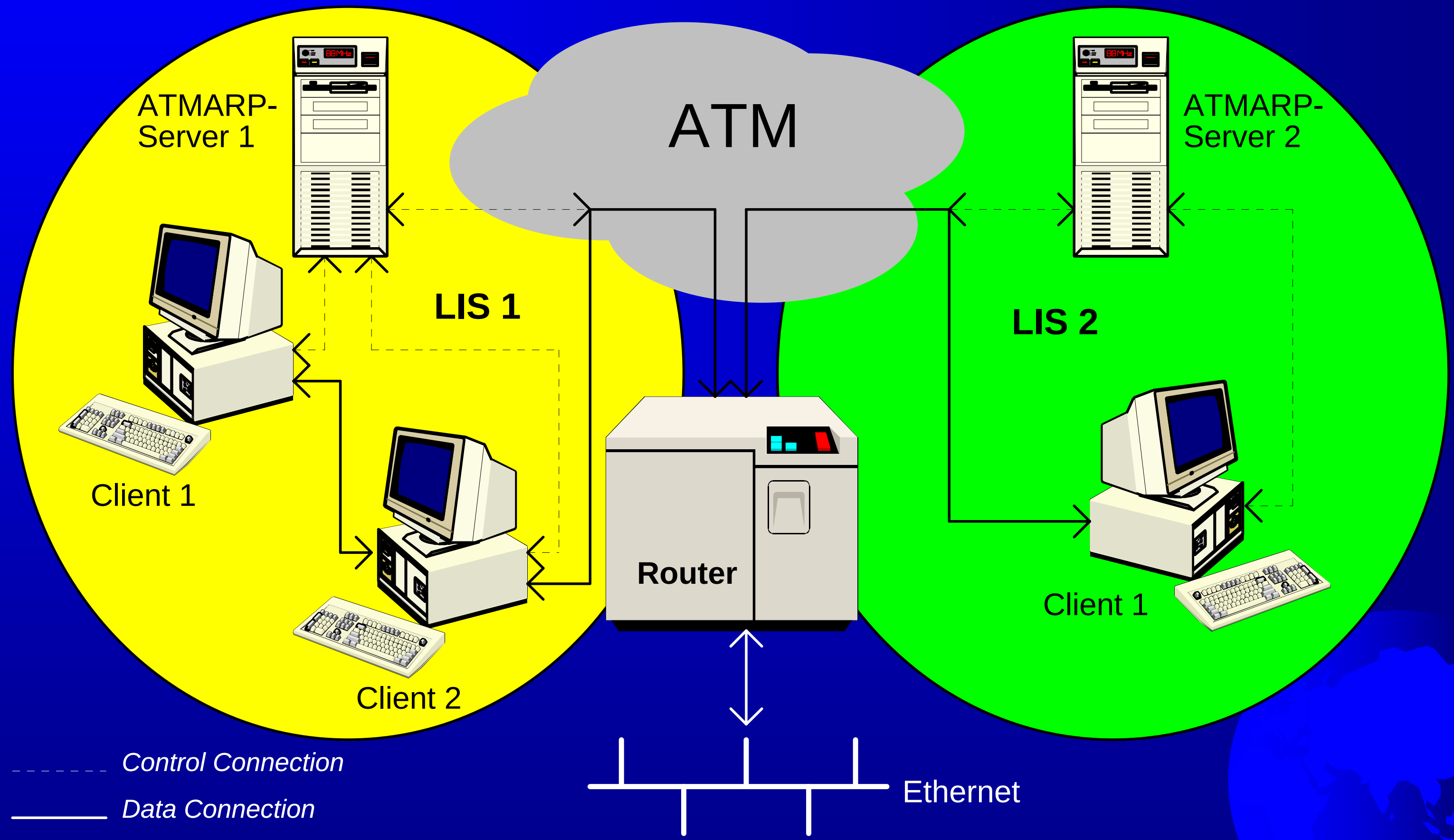
IP-over-ATM Adaptations

- Classical-IP
  - IETF: RFC-1577
  - ATM clients use IP
- LAN-Emulation (LANE)
  - ATM-Forum
  - Legacy networks use ATM
- Multiprotocol over ATM (MPOA)
  - ATM-Forum and IETF protocols
  - Routing mechanisms will be implemented

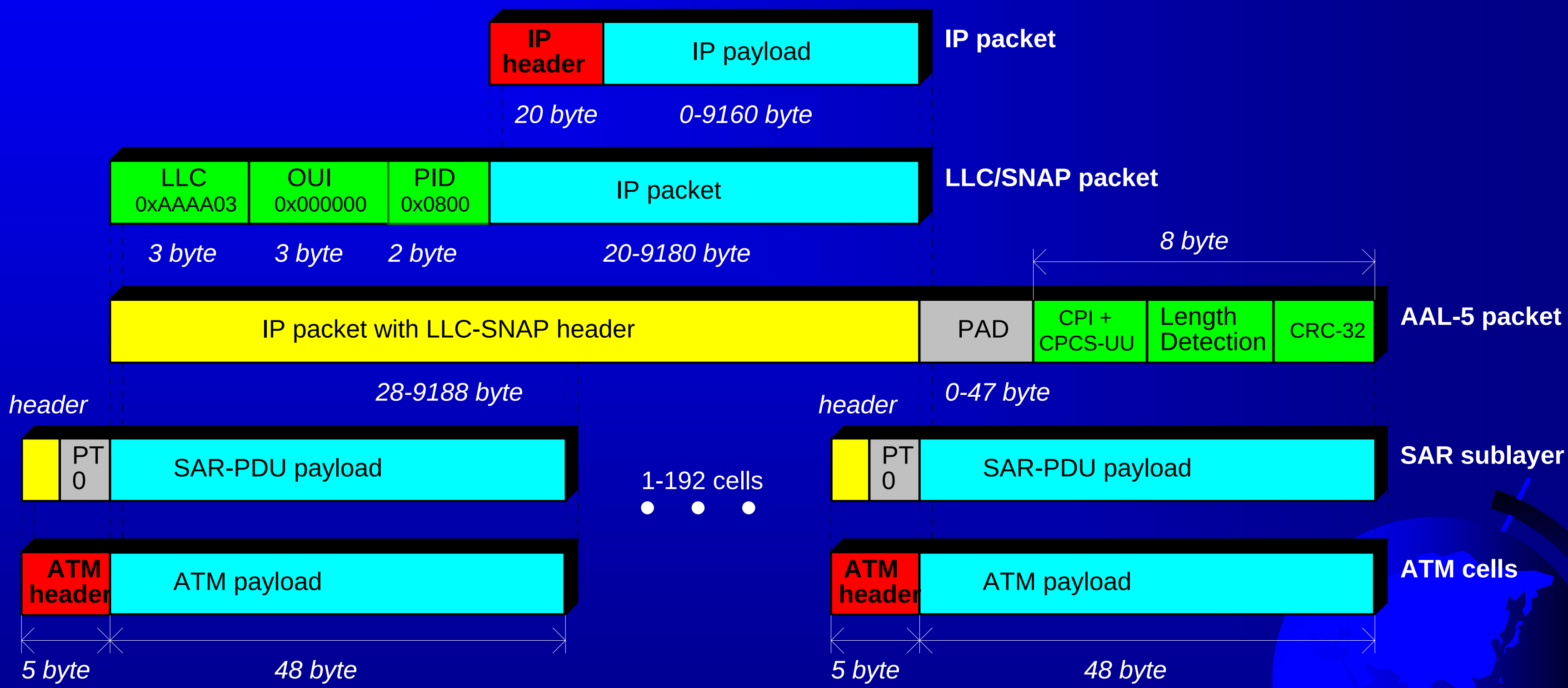
Classical-IP (RFC-1577)

- RFC-1577: Classical-IP and ARP over ATM
- Logical Link Control Encapsulation: Multiple protocols can be transported over a single connection (RFC-1483)
- VC-Based Multiplexing: Single protocol is transported over an ATM connection (RFC-1483)
- D-MTU: 9180 byte
- PVC/SVC connections
- Transport over the AAL-5 layer
- Point-to-point connections
- Address resolution by central ATMARP server

Classical-IP architecture



Encapsulation (RFC-1483)



RFC-1577 conclusions

- Advantages:
  - Simple and stabile standard
  - High data throughput by high MTU (9180 byte)
  - Fully compatible with IP, no changes to higher layer protocols and applications
- Disadvantages:
  - Only IP unicast is supported
  - High manual configuration effort
  - No multicast/broadcast support
  - No redundant ATMARP server (Single-Point-of-Failure)
  - No direct ATM connections across LIS borders supported
  - No re-use of LAN infrastructure
  - No QoS

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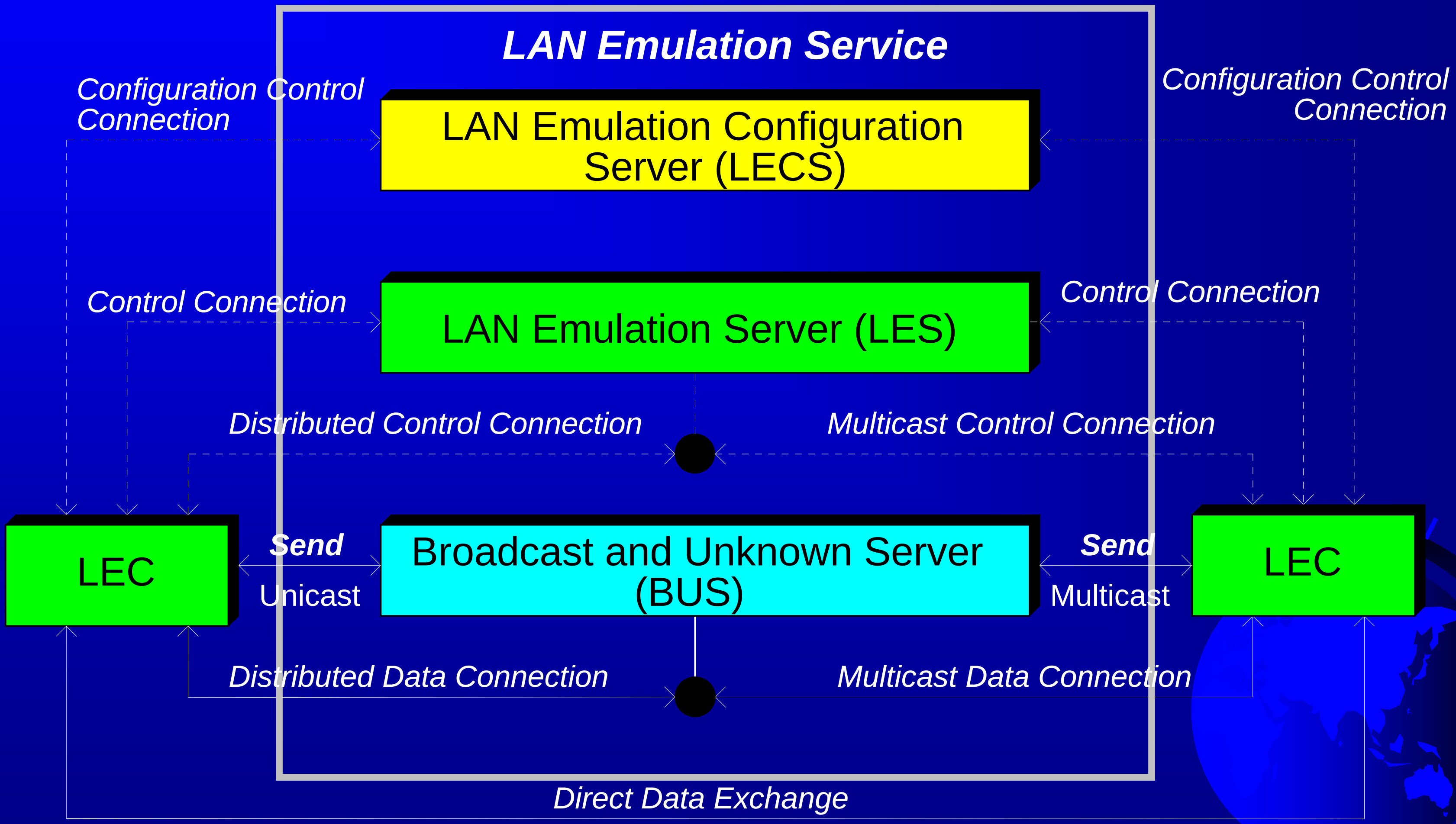
LAN Emulation (LANE)

- Migration of legacy LANs to ATM: Ethernet switch (layer 2) und router (layer 3) coupling
- Universal implementation (MAC layer is emulated): arbitrary LAN protocols
- Using of the application layer without ATM configuration
- Support of PVC/SVC connections
- AAL-5 packet encapsulation
- IP multicasting
- D-MTU: 1500 byte

LANE architecture



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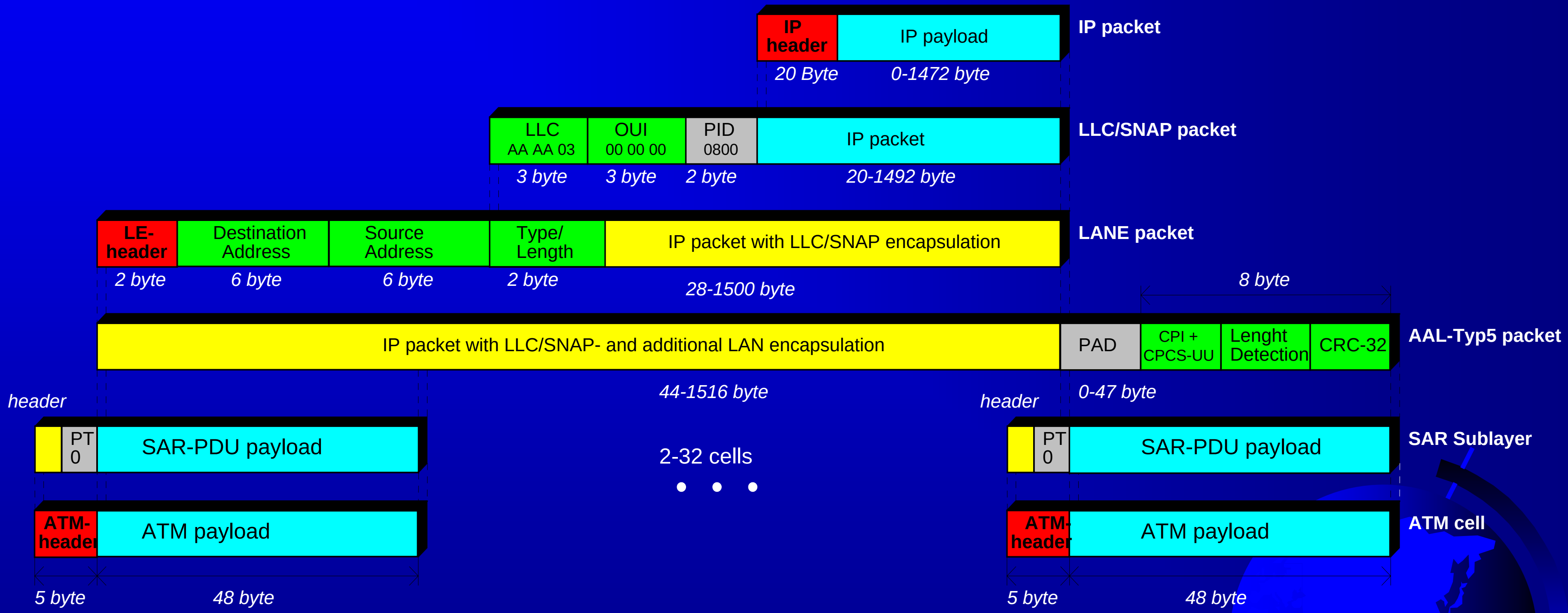
LANE encapsulation



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LANE conclusions

- Advantages:
  - Re-use of legacy LAN equipment, ATM can be used as fast backbone
  - No changes to IP, higher layer protocols and applications
  - Multicast/broadcast support
  - Automatic configuration
- Disadvantages:
  - LANE requires complex software (full UNI3.1 stack and LANE specific entities): high functionality (layer 2 emulation)
  - MTU size and older network boards and inefficient adaptations (IP-MAC-ATM) limitated throughput
  - Bad scalability: does not scale well (needs a lot of VCs per host)
  - Direct connections are only possible for traffic inside the ELAN
  - No redundant BUS (Single-Point-of-Failure) and no QoS

MPOA capacity

- Emulates a fully routed layer 3 protocol over ATM
- General approach for any layer 3 protocol (IP, IPX, ..)
- Distribute the routing functions between route servers
- Separate routing from switching functions
- Leverage performance and QoS capabilities of ATM network
- Direct connections between ELANs rather than passing through traditional routers
- Direct Virtual Channel Connections (VCC) between data forwarding devices
- Interworking with unified routers
- Enables subnet members to be distributed across the network
- Efficient scalability of the ATM network

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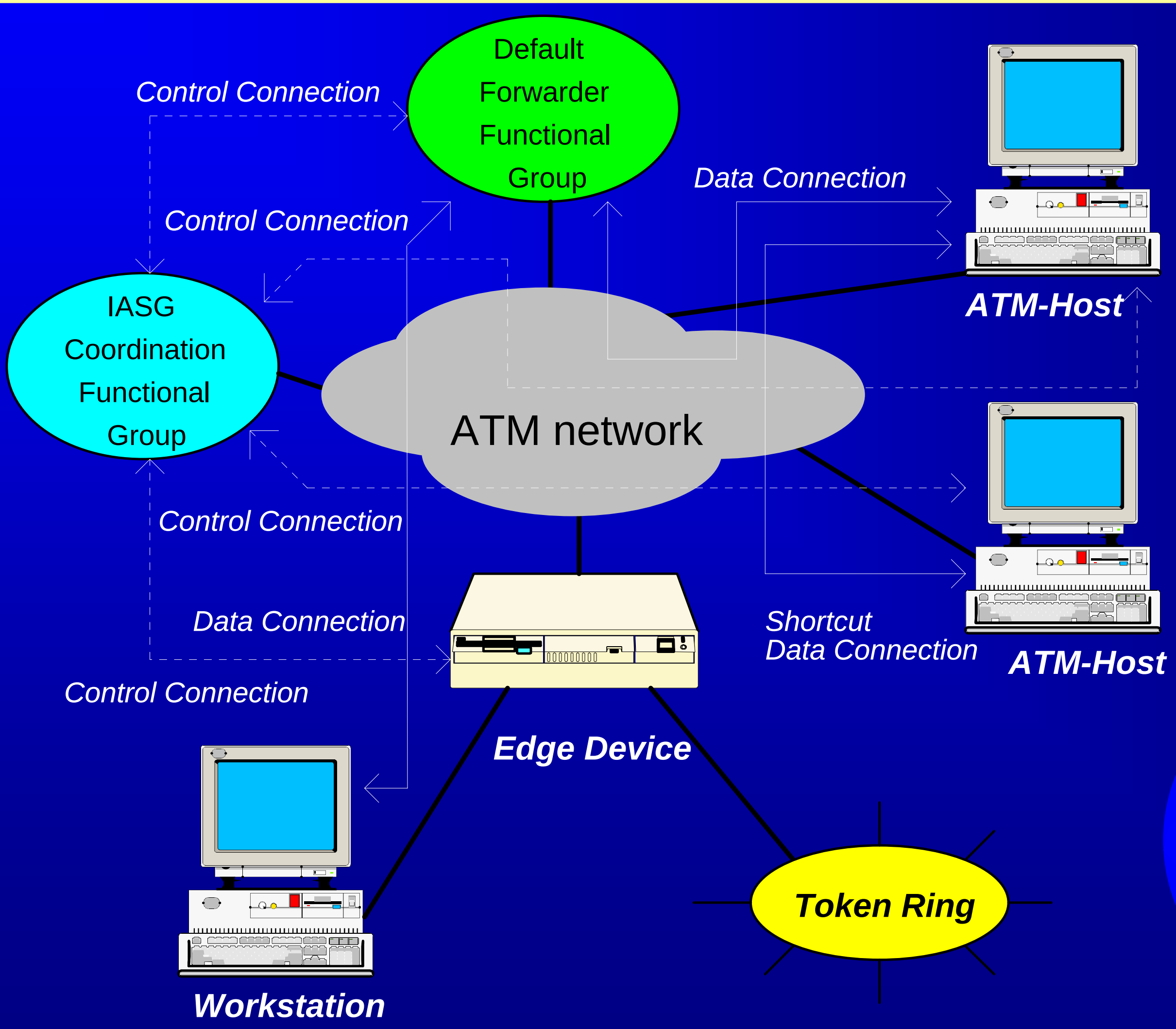
MPOA architecture



Extensions for MPOA attempts

- Multicast Address Resolution Server (MARS)
  - support of multicasting by additional MARS server
- Next-Hop Resolution Protocol (NHRP)
  - direct connection between subnets possible
- Resource Reservation Protocol (RSVP)
  - QoS parameter at connectionsless packets
  - similar to the UNI signaling
- Private Network-to-Network-Interface (P-NNI)
  - control data exchange between ATM systems
  - transparency pass on the virtual connection

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MPOA conclusions

- Advantages:
  - The model unifies the approaches of IETF and the ATM Forum
  - MPOA provides connectivity of a fully routed environment, supporting even multicast and broadcast
  - QoS is supported for the first time (but VCs are shared)
  - Direct VC connections in ATM networks are supported: router bottlenecks are eliminated
  - Management of large networks
  - Reduces infrastructure costs by separating cheap switching from expensive route computation
  - Build up of flexible Virtual Local Area Networks (VLANs)
- Disadvantages:
  - MPOA is not a full defined spezification (1998)
  - Scalability is an extremely complex issue

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IPoverATM Overhead

STM-1-Frame (OC-3):	155,52 Mbps
ATM Layer:	149,76 Mbps
Adaptation Layer AAL-5:	135,632 Mbps
LLC/SNAP encapsulation:	
- MTU: 576 byte	126,937 Mbps
- MTU: 9180 byte	135,22 Mbps
- MTU: 65527 byte	135,563 Mbps
Internet Protocol (IP):	125,2/135,1/135,6 Mbps
Transport Layer:	120,9/134,8/135,5 Mbps
Application Layer via TCP:	116,5/134,5/135,5 Mbps
Application Layer via UDP:	119,1/134,7/135,5 Mbps

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TCP-Throughput Obstacles

- Socket buffer size at sender/receiver
- Network: Maximum Transport Unit (MTU)
- Protocol: Maximum Segment Size (MSS)
- Sender: using of the Nagle's algorithm
- Round-Trip-Time (RTT)
- Receiver: delayed acknowledegements
- Sender: Silly Window Syndrom (SWS)
- Copy strategy at the socket interface
- Network congestion and lost packet notice

UDP performance

- Connectionless structure
- UDP has no acknowledgements, no end-to-end control and no duplicate detection
- Less locking effects for protect shared protocol state and data
- Locking Effects limits the data throughput

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Client performance

- Operation system (inter-process communication)
- Data processing
- CPU performance
- Memory speed
- I/O bus bandwidth
- ATM adapter implementation

Client Tuning

- Using of the D-MTU value
- Path-MTU: max. possible packet size should be switch on (none fragmentation)
- MSS value: 1436 byte for high speed networks
- Sender and receiver buffer at least 2 times bigger than MTU value
- Window Scale Option (RFC-1323) higher Window-Size

Classical-IP:	Throughput of 134,01 Mbps (Sun20-Ultra)
LAN-Emulation, test 1:	Throughput of 76,30 Mbps (Sun20-Ultra)
LAN-Emulation, test 2:	Throughput of 117,63 Mbps (Ultra-Ultra)

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...further developments

- Classical-IP, Version 2
  - distributed ATMARP server
  - QoS support with NHRP and IPv6
- LANE, Version 2
  - L-UNI: QoS, multicast, ELAN multiplexing
  - L-NNI: distributed LES/BUS
- IP/Tag-Switching (Ipsilon + CISCO)
  - Use ATM hardware and simple IP control software
  - Network establishes cut-through VCs - they can not be controlled by applications
  - none standard