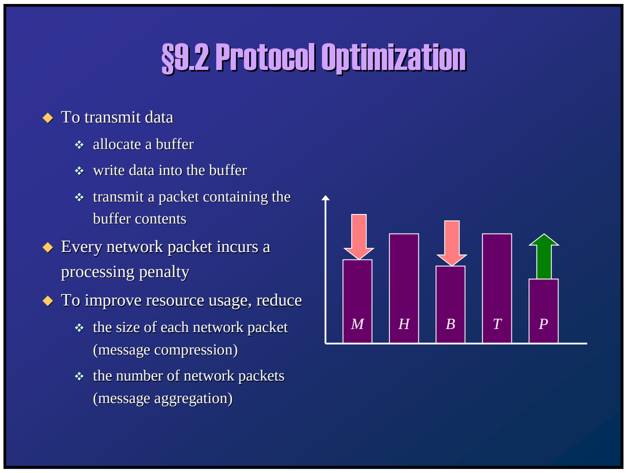
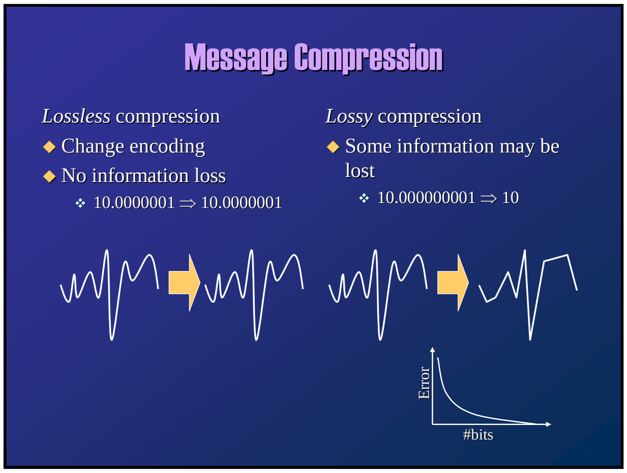


§9.2 Protocol Optimization

- To transmit data
  - allocate a buffer
  - write data into the buffer
  - transmit a packet containing the buffer contents
- Every network packet incurs a processing penalty
- To improve resource usage, reduce
  - the size of each network packet (message compression)
  - the number of network packets (message aggregation)



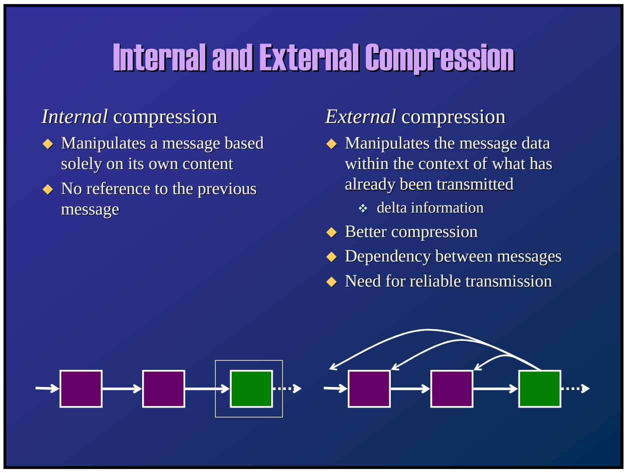
Message Compression

Lossless compression

- Change encoding
- No information loss
  - 10.0000001 ⇒ 10.0000001

Lossy compression

- Some information may be lost
  - 10.000000001 ⇒ 10



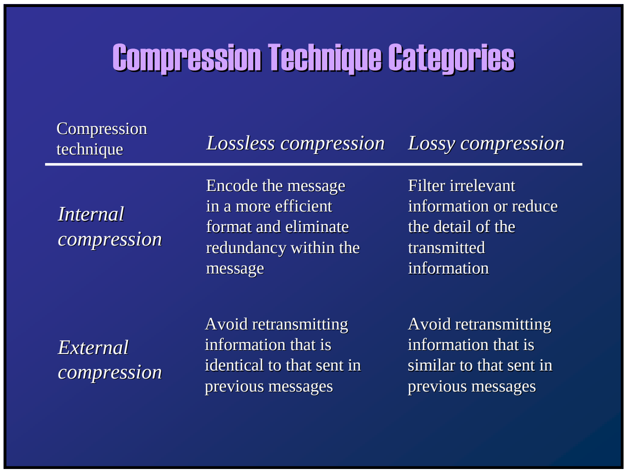
Internal and External Compression

Internal compression

- Manipulates a message based solely on its own content
- No reference to the previous message

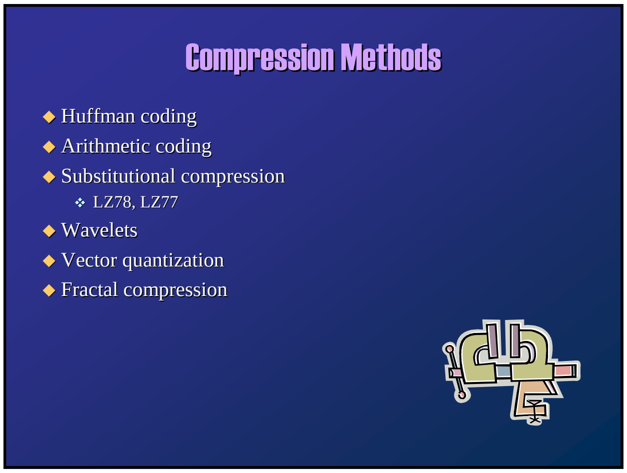
External compression

- Manipulates the message data within the context of what has already been transmitted
  - delta information
- Better compression
- Dependency between messages
- Need for reliable transmission



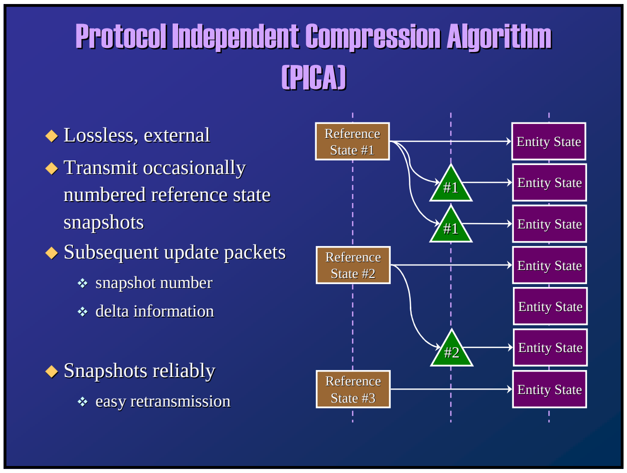
Compression Technique Categories

Compression technique	*Lossless compression*	*Lossy compression*
Internal compression	Encode the message in a more efficient format and eliminate redundancy within the message	Filter irrelevant information or reduce the detail of the transmitted information
External compression	Avoid retransmitting information that is identical to that sent in previous messages	Avoid retransmitting information that is similar to that sent in previous messages



Compression Methods

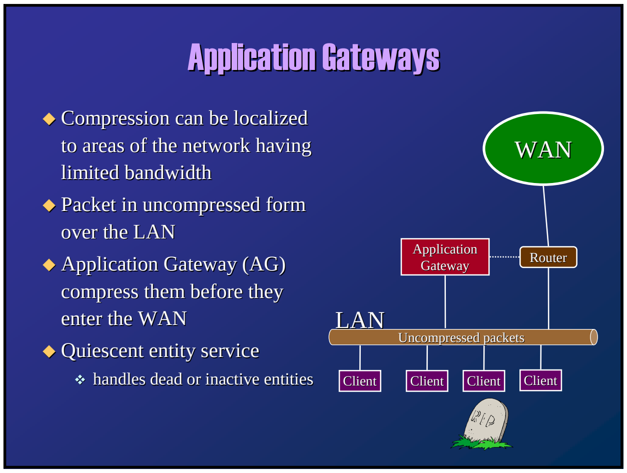
- Huffman coding
- Arithmetic coding
- Substitutional compression
  - LZ78, LZ77
- Wavelets
- Vector quantization
- Fractal compression



Protocol Independent Compression Algorithm (PICA)

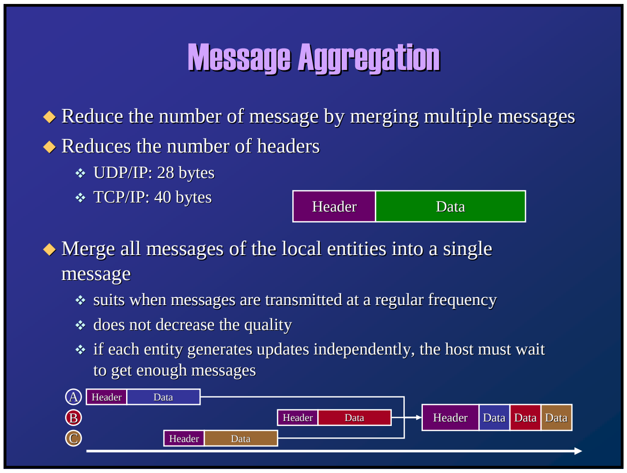
- Lossless, external
- Transmit occasionally numbered reference state snapshots
- Subsequent update packets
  - snapshot number
  - delta information
- Snapshots reliably
  - easy retransmission

Reference State #1
Entity State
#1
Entity State
#1
Entity State
Reference State #2
Entity State
Entity State
#2
Entity State
Reference State #3
Entity State



Application Gateways

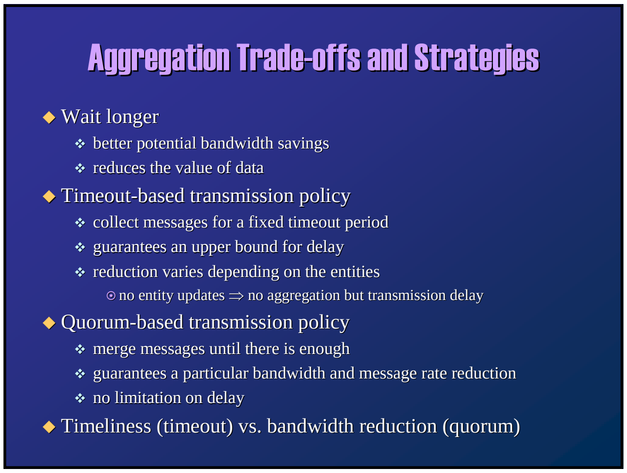
- Compression can be localized to areas of the network having limited bandwidth
- Packet in uncompressed form over the LAN
- Application Gateway (AG) compress them before they enter the WAN
- Quiescent entity service
  - handles dead or inactive entities



Message Aggregation

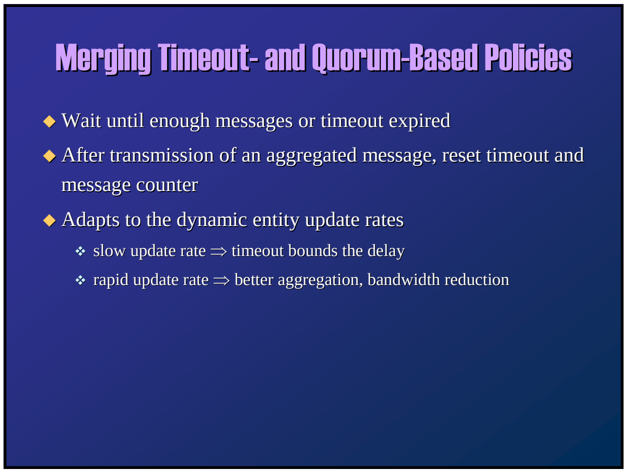
- Reduce the number of message by merging multiple messages
- Reduces the number of headers
  - UDP/IP: 28 bytes
  - TCP/IP: 40 bytes
- Merge all messages of the local entities into a single message
  - suits when messages are transmitted at a regular frequency
  - does not decrease the quality
  - if each entity generates updates independently, the host must wait to get enough messages

Header
Data
A
Header
Data
B
Header
Data
C
Header
Data
Header
Data
Data
Data



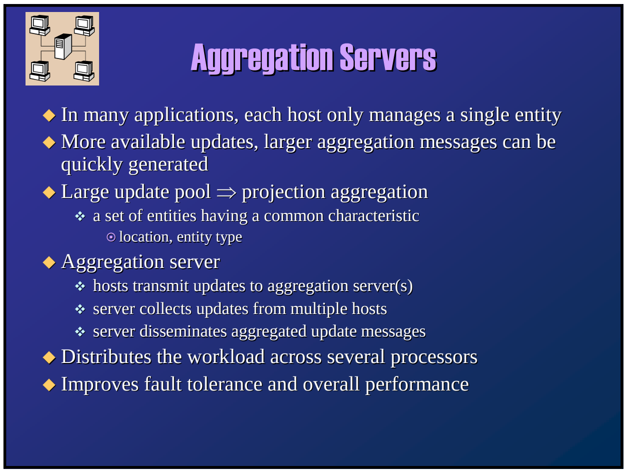
Aggregation Trade-offs and Strategies

- Wait longer
  - better potential bandwidth savings
  - reduces the value of data
- Timeout-based transmission policy
  - collect messages for a fixed timeout period
  - guarantees an upper bound for delay
  - reduction varies depending on the entities
    - no entity updates ⇒ no aggregation but transmission delay
- Quorum-based transmission policy
  - merge messages until there is enough
  - guarantees a particular bandwidth and message rate reduction
  - no limitation on delay
- Timeliness (timeout) vs. bandwidth reduction (quorum)



Merging Timeout- and Quorum-Based Policies

- Wait until enough messages or timeout expired
- After transmission of an aggregated message, reset timeout and message counter
- Adapts to the dynamic entity update rates
  - slow update rate ⇒ timeout bounds the delay
  - rapid update rate ⇒ better aggregation, bandwidth reduction



Aggregation Servers

- In many applications, each host only manages a single entity
- More available updates, larger aggregation messages can be quickly generated
- Large update pool ⇒ projection aggregation
  - a set of entities having a common characteristic
    - location, entity type
- Aggregation server
  - hosts transmit updates to aggregation server(s)
  - server collects updates from multiple hosts
  - server disseminates aggregated update messages
- Distributes the workload across several processors
- Improves fault tolerance and overall performance