ALERT-2 Protocol Development Project

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ALERT-2

Topics

- ALERT-2 Phase I Project

- Media Access Control (MAC) Protocol Analysis

- ALERT-2 Phase II Proposal

ALERT-2 Phase I Project

Phase I Project

Overview

- Six-month project funded by NOAA

- Preliminary work on ALERT-2 protocols

  - Almost everything from the modem to the sensor/data logger/database

- July 2007 – January 2008

Phase I Project

Results

- ALERT-2 Requirements Specification

- Preliminary ALERT-2 Protocol Specification

- ALERT-2 project Web site
  - http://www.alert-2.com/

Phase I Project

Focus

- Larger than-expected focus on:
  - Ensuring that correct problem is being solved (the right requirements)
    - Eliciting requirements from ALERT community
  - Evangelizing technology
    - I am a computer scientist, not a hydrologist!

Phase I Project

Requirements Elicitation

- "ALERT into the Future" (SAAS 2006)

- 2006 SAAS Conference

- 2007 NHWC Conference

- Proceedings from other SAAS, NHWC, and AUG conferences

- FloodSystems Archives

- Meetings, phone calls, e-mails, and conversations

Phase I Project

ALERT-2 Working Meetings

- Sacramento, CA
  - October 24, 2007
- Longmont, CO
  - January 10, 2008
- Sacramento, CA
  - April 17, 2008

Phase I Project

Requirements Specification

- Summarized user (less technical) ALERT-2 requirements

- Document available:

  - http://www.alert-2.com/

- I would love to hear any questions, comments you have!

Phase I Project

Requirements Specification

- Continue to support real-time, best-effort sensor data

  - (Do what original ALERT protocol does)

- Improve performance

  - Blue Water Design's ALERT-2 modem is a big step forward

  - But, collisions, packet loss won't go away

Requirements Specification

- Improve functionality

  - Larger networks

  - More sensors

  - More sensor types

  - More data

  - ...

- Provide extensibility

  - Enable protocol to evolve

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Requirements Specification

- Operators should be able to manage their networks remotely

  - Poll remote stations for status, data

  - Command actuators at remote stations

  - Download log files over network

  - Upload new configurations (e.g., to repeaters)

  - "That would be awesome"

Phase I Project

Requirements Specification

- ALERT-2 should provide:
  - Best-effort, datagram service
    - Just like original ALERT protocol, only better
  - Optional reliable datagram service
    - Ensure that a single packet is really received
    - Useful for commands, ...
  - Optional reliable byte stream service
    - Reliably transfer files
      - Log files, configuration files, ...

Phase I Project

Requirements Specification

- Optional, reliable services require two-way communications!

  - "This isn't the way we have been doing things"

Phase I Project

Preliminary Protocol Specification

- A preliminary set of protocols was described

  - Link, network, transport protocols

- Document available on project Web site:

  - http://www.alert-2.com/

- But, collisions (packet loss) won't go away without a good "media access control" (MAC) protocol

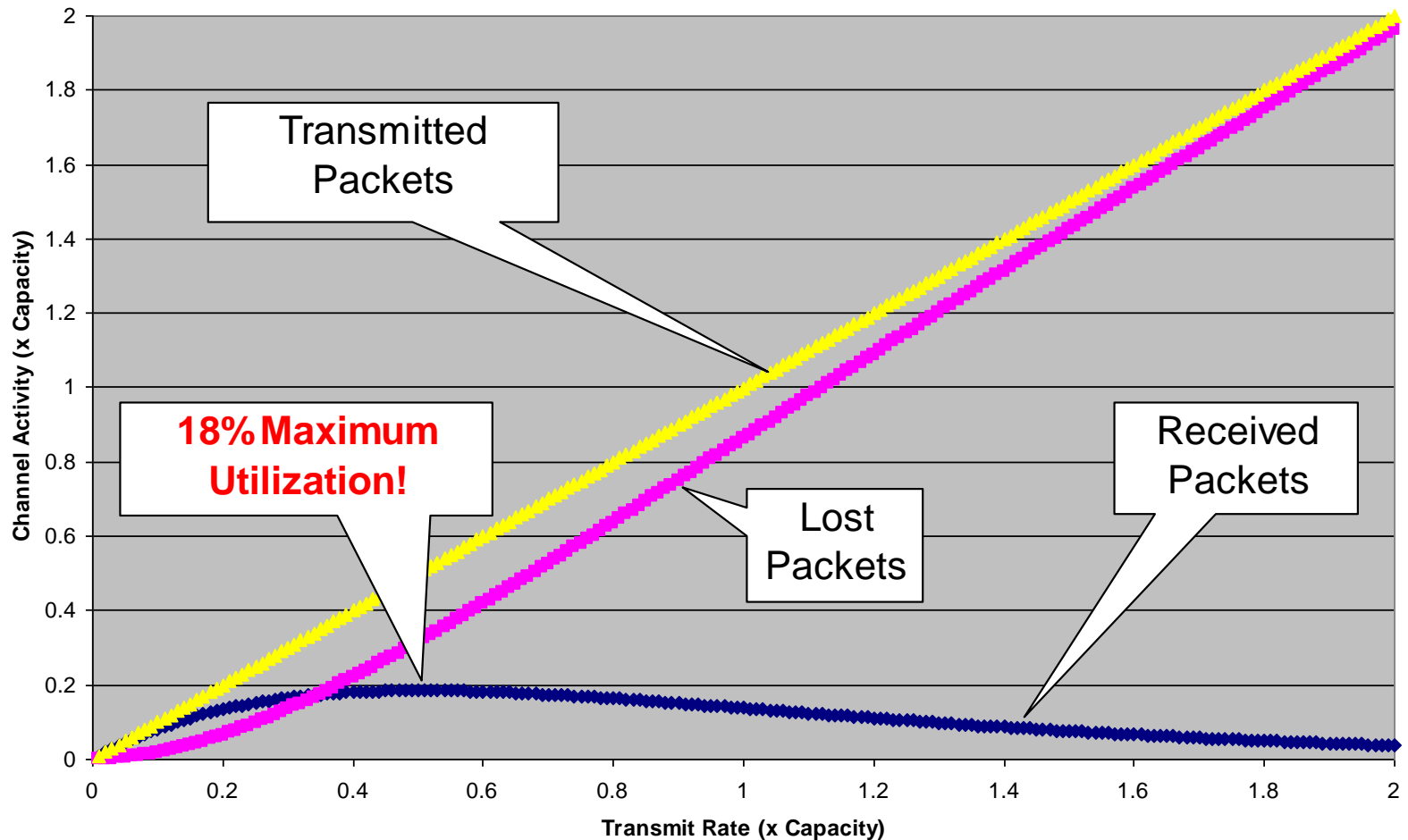# Media Access Control (MAC) Protocol Analysis

MAC Protocol Analysis

Media Access Control (MAC) Protocols

- Controls which station can transmit when

- Original ALERT protocol uses Pure ALOHA protocol

  - Stations transmit whenever they want

- Some ALERT systems use Carrier Sense / Multiple Access (CSMA) protocol
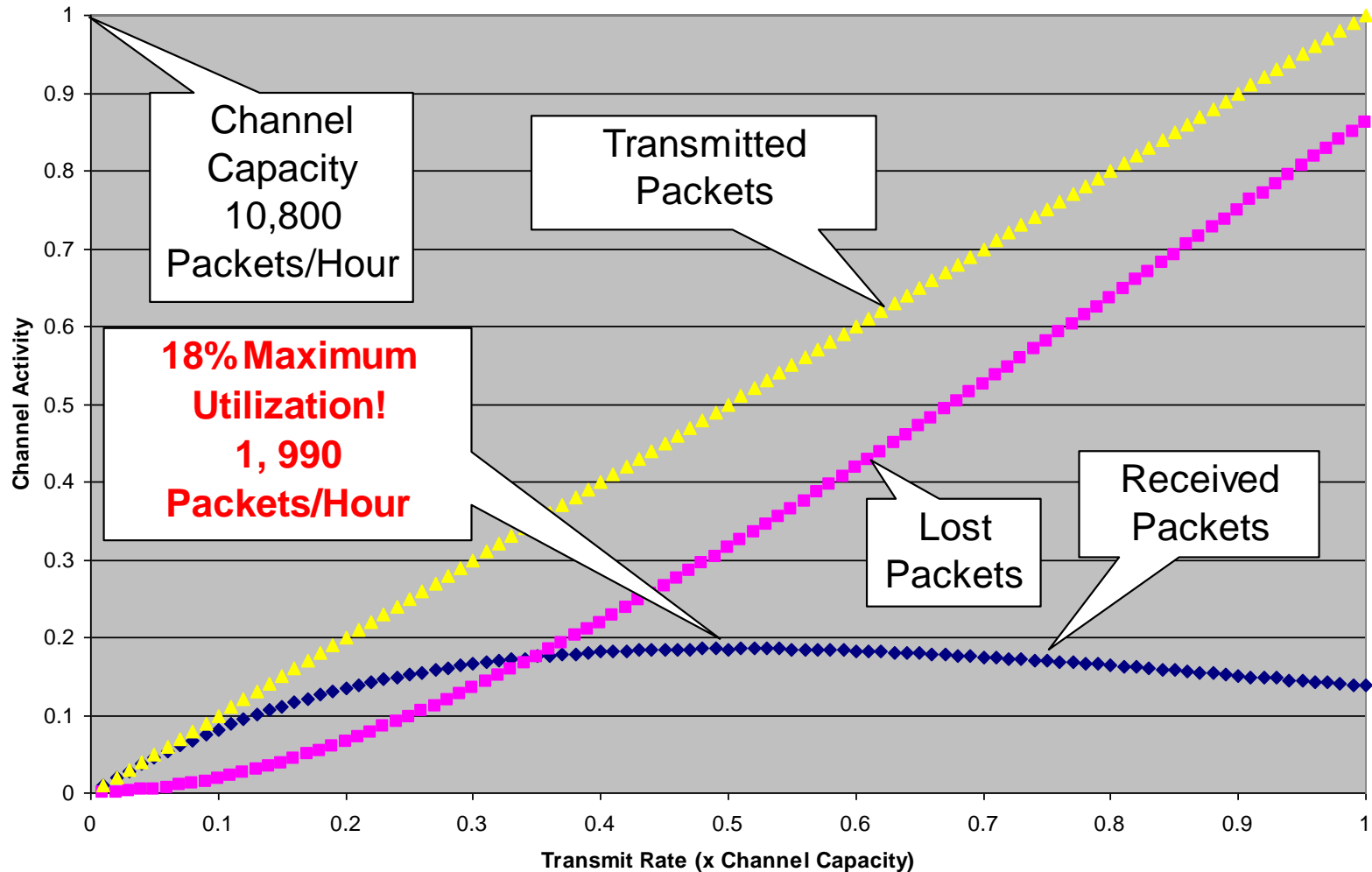
  - Stations listen for clear channel before transmitting

MAC Protocol Analysis

Approach

- Constructed discrete event simulation software

- Evaluating MAC protocols, station characteristics

MAC Protocol Analysis

**Pure ALOHA
(Always Talk, Never Listen)**

MAC Protocol Analysis

Pure ALOHA

Channel Capacity 10,800 Packets/Hour

Transmitted Packets

18% Maximum Utilization! 1, 990 Packets/Hour

Lost Packets

Received Packets

Channel Activity
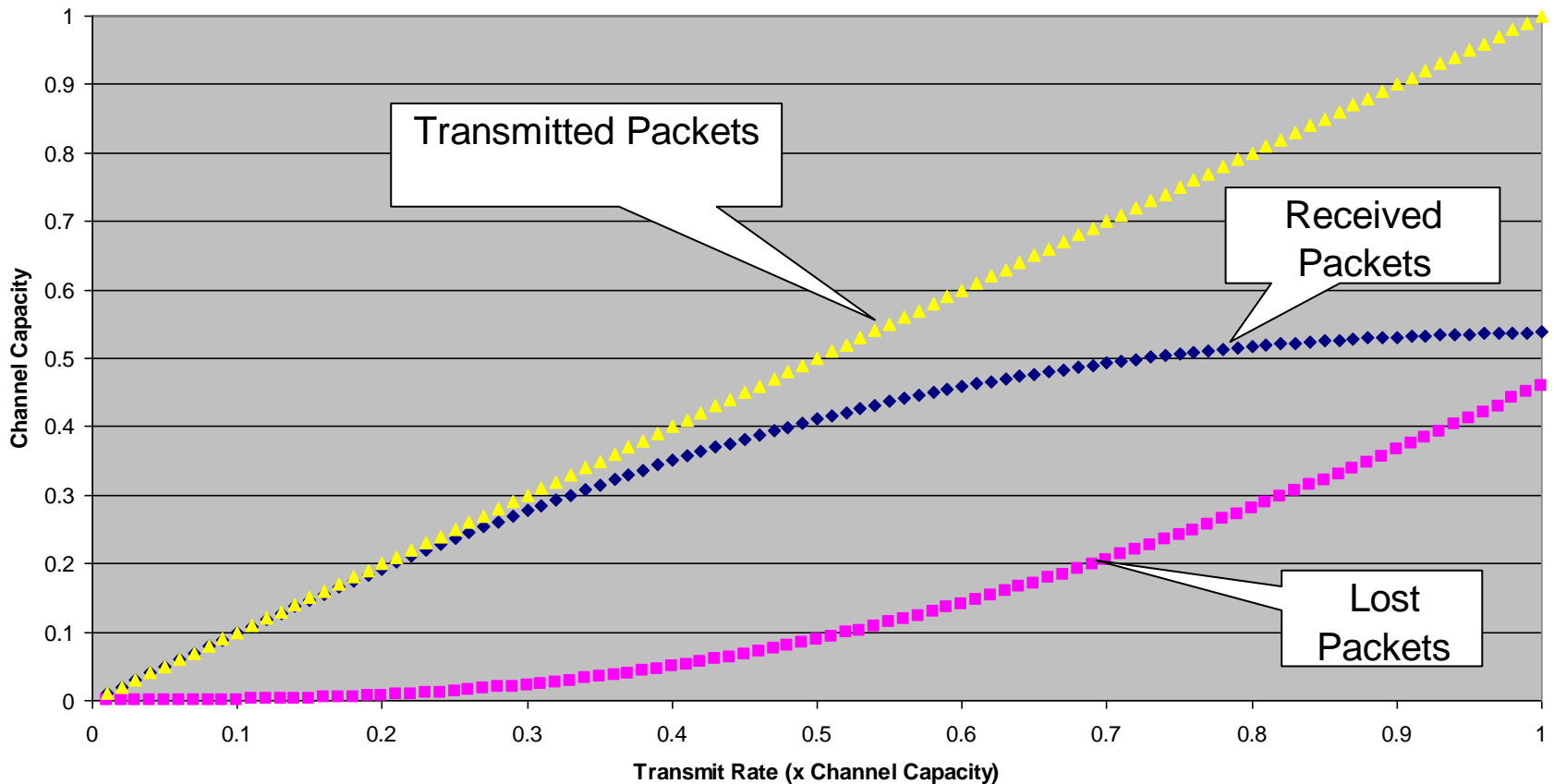
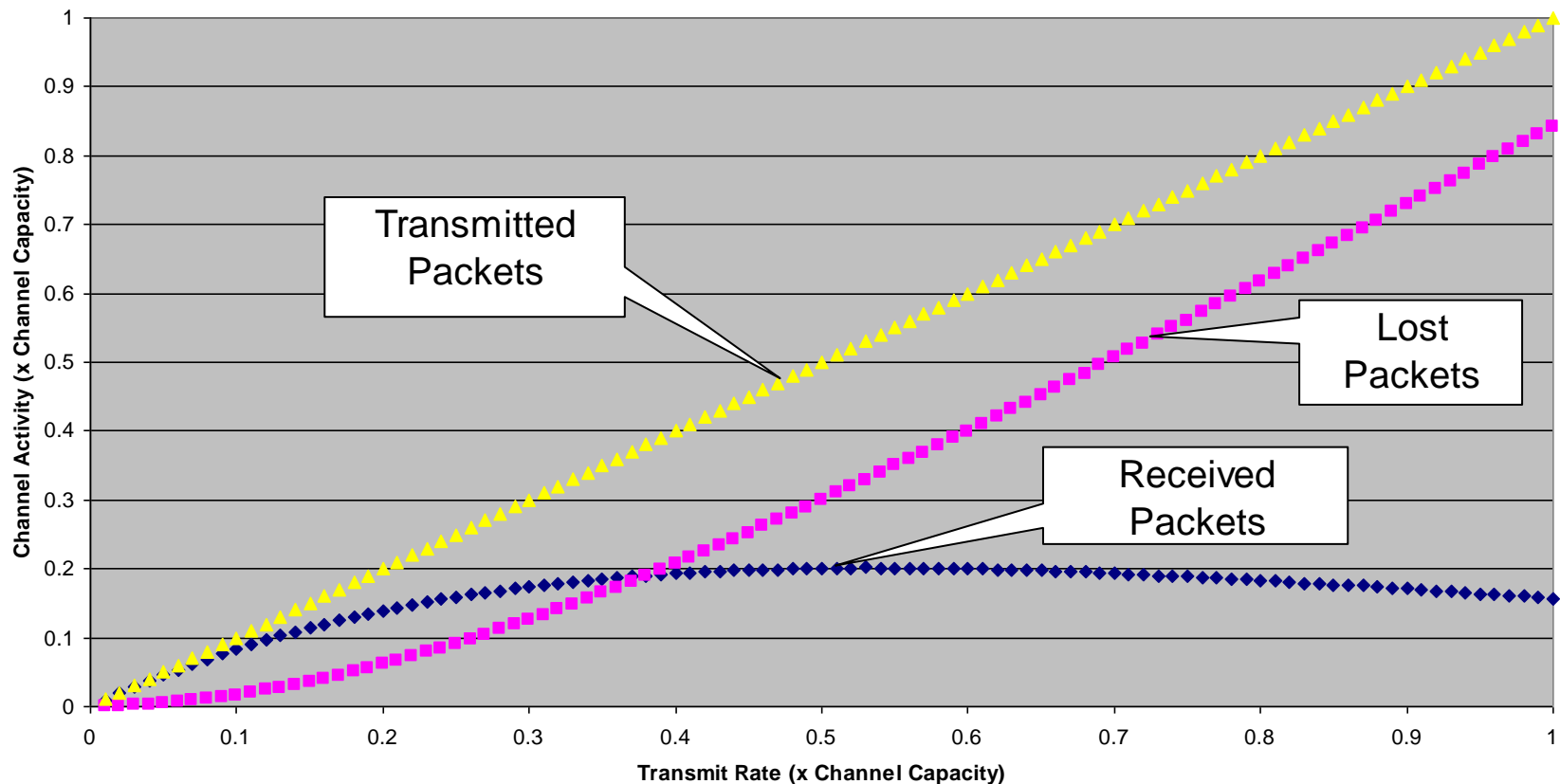**Transmit Rate (x Channel Capacity)**

Pure ALOHA Protocol

- Maximum channel utilization of 18%

  - But, 63% packet loss

- Results independent of:

  - Packet size

    - Bytes or time

  - Number of nodes

  - Transmission speed

  - ...

Perfect Carrier Sense/Multiple Access (CSMA)
(Listen before transmitting)

Real-World CDMA
(10 Broadcast Domains)

Chart title: Real-World CDMA (10 Broadcast Domains). Y-axis: Channel Activity (x Channel Capacity), ranging 0 to 1. X-axis: Transmit Rate (x Channel Capacity), ranging 0 to 1. Series shown: Transmitted Packets, Lost Packets, Received Packets.

MAC Protocol Analysis

Carrier Sense / Multiple Access

- Highly beneficial in theory

- Hard to make work in the real world
  - Stations don't hear all other stations
    - The hidden terminal problem
  - Receive/Transmit Turnaround time
    - Differences between voice-grade radios and data-grade radios
  - ...
  - Note: These results are preliminary

MAC Protocol Analysis

Time-Slotted MAC Protocols

- "A time-slotted MAC protocol could be a big win"

- Assign each station a time slot in which they must transmit

  - Multiple stations could have the same time slot

Hybrid MAC Protocols

- Hybrid time-slotted/ALOHA protocol:
  - Time-slotted access to avoid collisions
  - ALOHA protocol to minimize latency

Benefits

- A good MAC protocol can:
  - Control or eliminate collisions
  - Allocate bandwidth:
    - To different users
    - To different uses
    - Protect real-time sensor data from other activity

ALERT-2 Phase II Proposal

Phase II Proposal

Proposal Status

- Proposal submitted March 3
- Oral presentation May 14
- Approximate start date (if awarded) August 1, 2008

Phase II Proposal

Objectives

- Develop ALERT-2 Computer Module (ACM)

- Implement ALERT-2 protocols

- Field trial ALERT-2 software, ACM

- Update ALERT-2 protocol spec

- Standardize ALERT-2 protocols

Phase II Proposal

ALERT-2 Computer Module (ACM)

- Commercial, off-the-shelf hardware
  - *No hardware development!*
- Small, energy-efficient single-board computer (SBC)
- Linux
- Intended to enable early field trials
- Future as a product unclear

Phase II Proposal

ALERT-2 Protocols

- Based on Phase I work

- Include

  - MAC protocol (under development)

  - Link protocol

  - Network protocol

  - Transport protocols

  - Some application protocols

ALERT-2 Protocols

- Support both transmit-only and receive capable nodes and networks

Phase II Proposal

ALERT-2 Protocols

- Provide

  - One-way best-effort datagram service

    - Equivalent to original ALERT service

    - Roughly analogous to UDP

  - Reliable datagram service

    - Roughly analogous to Reliable UDP

  - Reliable byte-stream service

    - Roughly analogous to TCP

ALERT-2 Protocols

- Application protocols
  - Hydrologic sensor data
  - Backbone multiplexing
  - Basic file transfer
  - Basic network monitoring/management

Phase II Proposal

ALERT-2 Applications

- Backbone concentration

- Hydrologic sensor data collection

- Hydrologic sensor data archiving

- Basic network monitoring and management

- Basic file transport

- Network monitor