WAMS Communications and Standards

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Outline

- Communications for WAMS
  - Communication systems
  - Interfacing
- Types of WAMS & needs
- Delay and bandwidth
- Standards & protocols

WAMS communications

- Local WAMS
  - Data recorded on site
  - Available after fact for analysis
- Remote WAMS
  - Data sent in real-time to control center
- Common considerations
  - Sufficient data comm for reasonable access
  - Access security
    - From mischief by hackers or opponents
    - From people who could use to advantage (marketers)
  - Basic data communication chain

Communication Chain

- User equipment (terminal equipment)
  - DAS, PMU, recording, display, etc.
- Interface unit
  - Modems, CSU/DSU, SRU, etc.
- Communication system

Communication Specifications

- Analog specification
  - Basic VG36 (US West), voice grade channel
    - Same as standard analog phone line
  - Group-level with several channels combined
- Digital specification
  - DS0 (1 channel), 56K or 64K, usually DDS, ISDN
  - Multiple channel aggregation (N x 64K)
  - T1 (1.544 Mbps)
  - DS3 (44.736 Mbps), OC12 (622.08 Mbps), etc.
  - WAN, Internet

Interface to Communication System

- Probably the most difficult part to specify
  - Standards often unclear or not implemented properly
- Most common equipment connections
  - RS232
  - Ethernet in various configurations
- Most common communication system connections
  - Analog channel
  - Digital channel (serial interfaces)
  - Wideband digital
  - Internet
- Many connection specifications common to both

Interface units

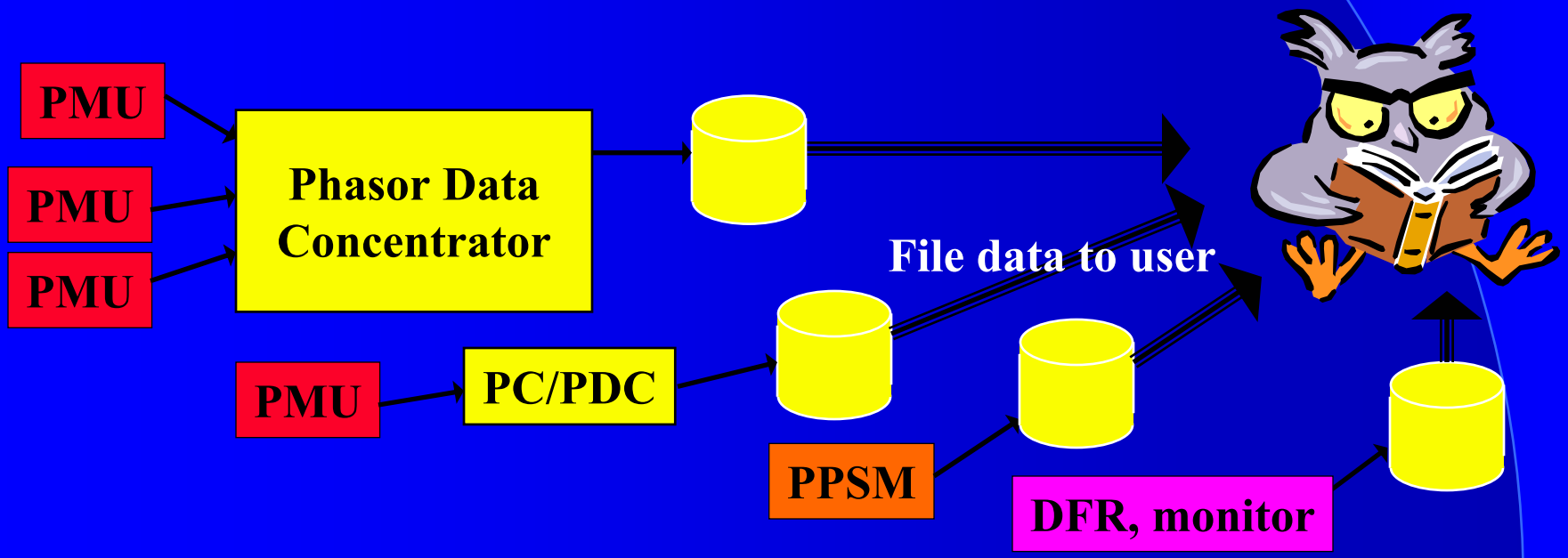
- Provide buffering and speed translation
- Analog modem
  - Can be used with digital and analog systems
  - Probably the easiest to implement reliably
- Digital channel
  - Digital modem, CSU/DSU, adapter, etc
  - Many standards, careful to pick
- Router/bridge
  - Used for high-speed links
  - Connect Ethernet, T1, Internet, WAN

Local vs Remote WAMS

- Local WAMS
  - Sufficient recording required on-site
  - Recording is more secure – does not depend on communications directly
  - Data can be retrieved by visit – does not depend on communications
- Remote WAMS
  - Communication system speed & latency important
  - Operation monitoring at control center inherent
  - Data available for real-time operation & control
  - Recorded data readily available at control center

Local WAMS

- Phasor Measurements Principal Data Source
- Data stored in compatible file types
- Files exchanged by Email, FTP, Web site, Disc, CD
- Minimal data communication requirements

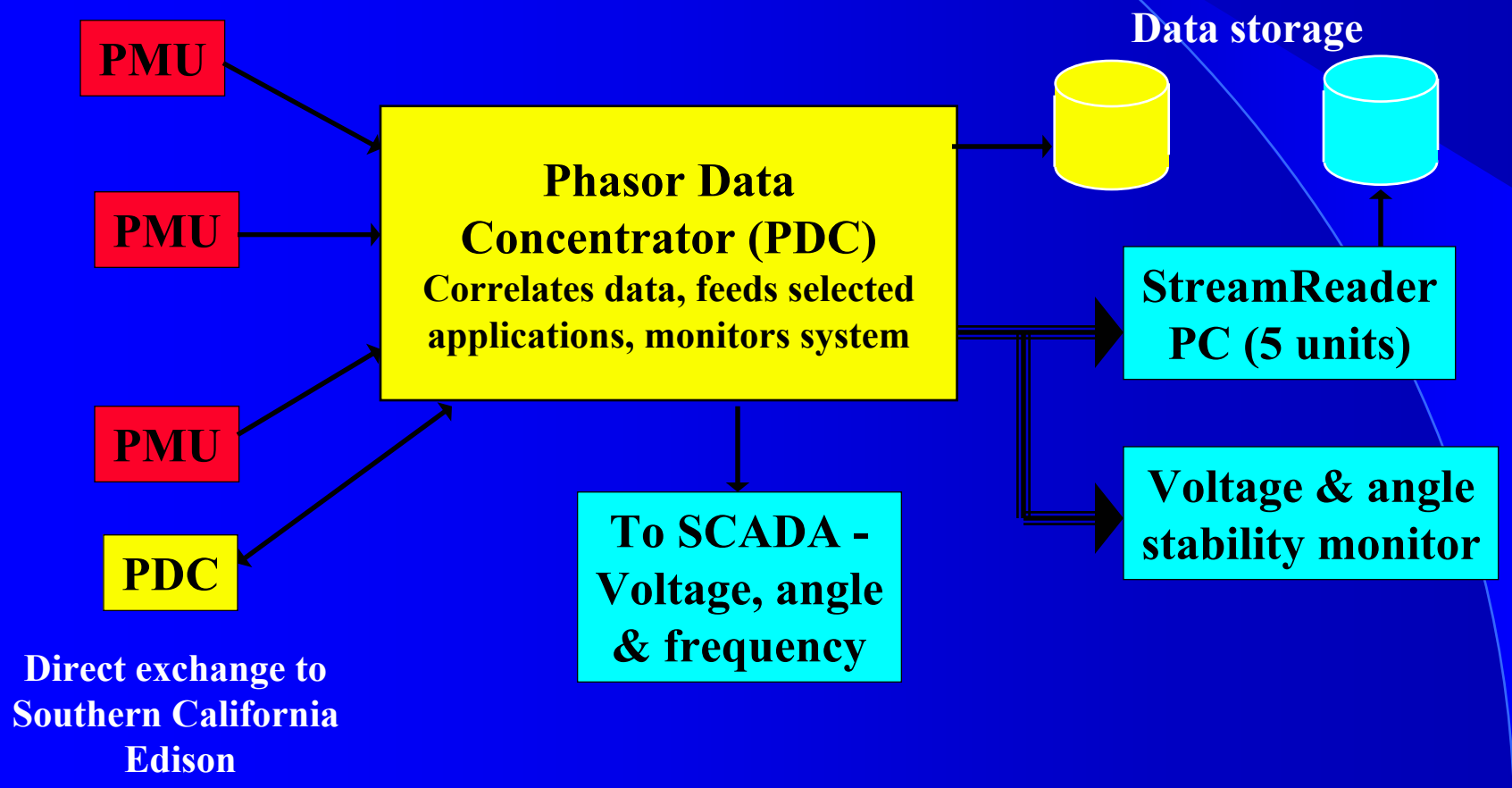


Local WAMS

- Local recording WAMS requirements
  - Reasonable data storage
  - File size vary by type, data stored
    - Eg: “.dst” format, 5 phasors, frequency, 5 minute length
      - 130K for 12 sample/sec data rate
      - 648K for 60 samples/sec data rate
- Communications for file transfer, maybe status
  - Access port needs security
  - Speed not critical. Eg. Data transfer of a 1 MB file size -
    - 4.9 min at 33.6 Kbps
    - 6.9 sec at 1.5 Mbps

Remote WAMS

- Continuous, real-time data flow
- Reporting, display & recording provided



Remote WAMS

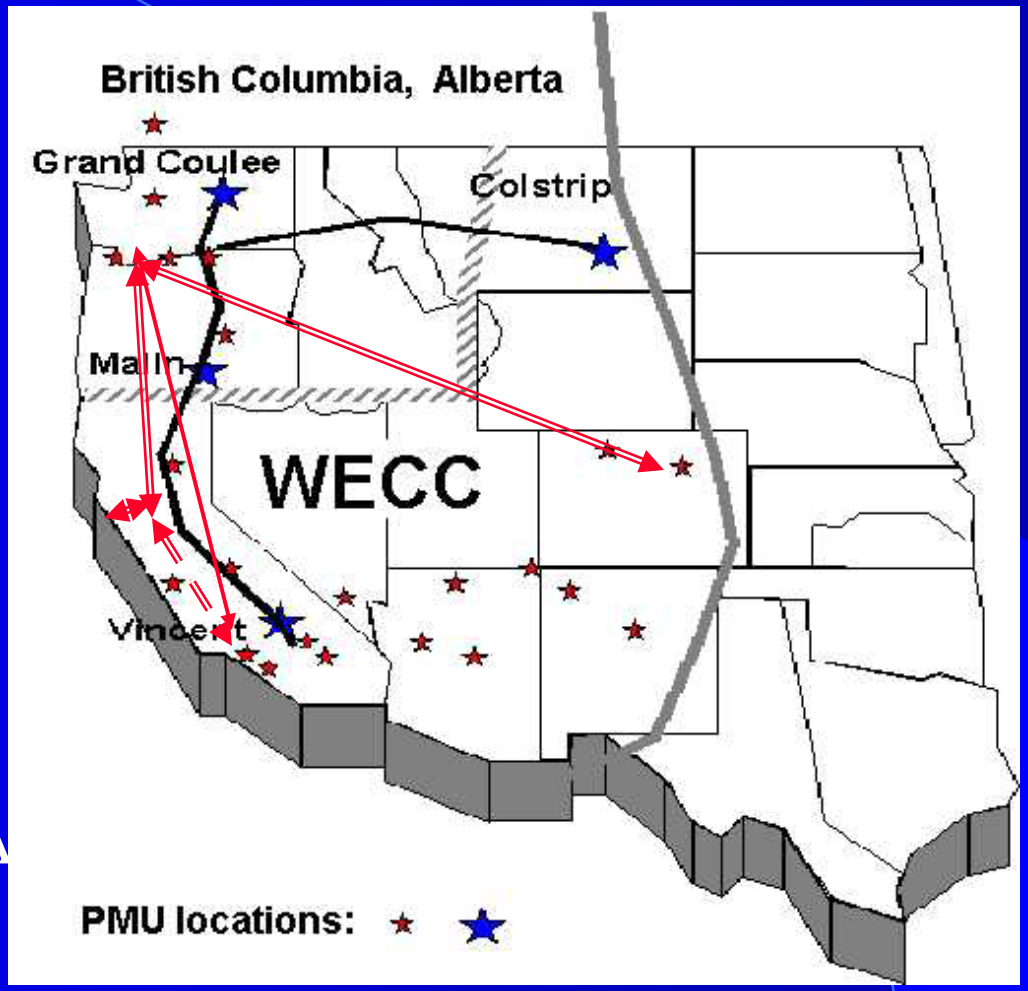
- Communication system critical element
  - Lost data not available for real-time or analysis
  - Operation & controls require suspension
- Communication system requirements
  - Speed (bandwidth) sufficient continuous operation
    - Variable rate systems must handle data at lowest expected rate
  - Latency important for control applications
    - Operations needs much slower – but check buffering

Real-time WAMS data display

- Stream reader with user selected traces
- Records continuously on PC file system

Inter-utility WAMS

- BPA-SCE
  - Limited data
  - Uses analog channel
  - Since 1998
- BPA-CAISO
  - Full data flow, T1 link
  - Since 9/2002
- BPA-WAPA
  - Full data, T1
  - This year
- CAISO-SCE-PG&E-BPA
  - Full data, selected units
  - 2003-2004



Bandwidth and Latency

- Bandwidth is how much information can pass in a given period of time
  - Commonly called speed or baud
    - 14.4K modem can send/receive 14,400 bits/sec
    - 10BaseT sends/receives 10,000,000 bits/sec
  - Will vary by impairment, compression, overhead
- Latency defines how long information takes from one point to another
  - Time for a bit or message to leave one point and arrive at another
  - Only important in real-time monitoring or controls
    - Monitoring (human-visual) insensitive to latency < 300 ms
    - Controls sensitive to latency in 10 ms range (or less)

WAMS Bandwidth Requirements

Data rates shown in bytes/sec. Figure BW <u>requirements in bits/sec</u>

Async serial – 2 bits/character overhead

Ethernet – 22 bytes/frame overhead

A reasonable estimate is:

Rate * 10 = bits/sec (BPS)

Eg: pt on wave, 720/sec, 6 chn

11520 * 10 = 115.2 KBPS

Phasor data with IEEE protocol

Data rate - bytes/sec

Smp/sec	2 Phasor	5 Phasor	10 Phasor
12	336	480	720
30	840	1200	1800
60	1680	2400	3600

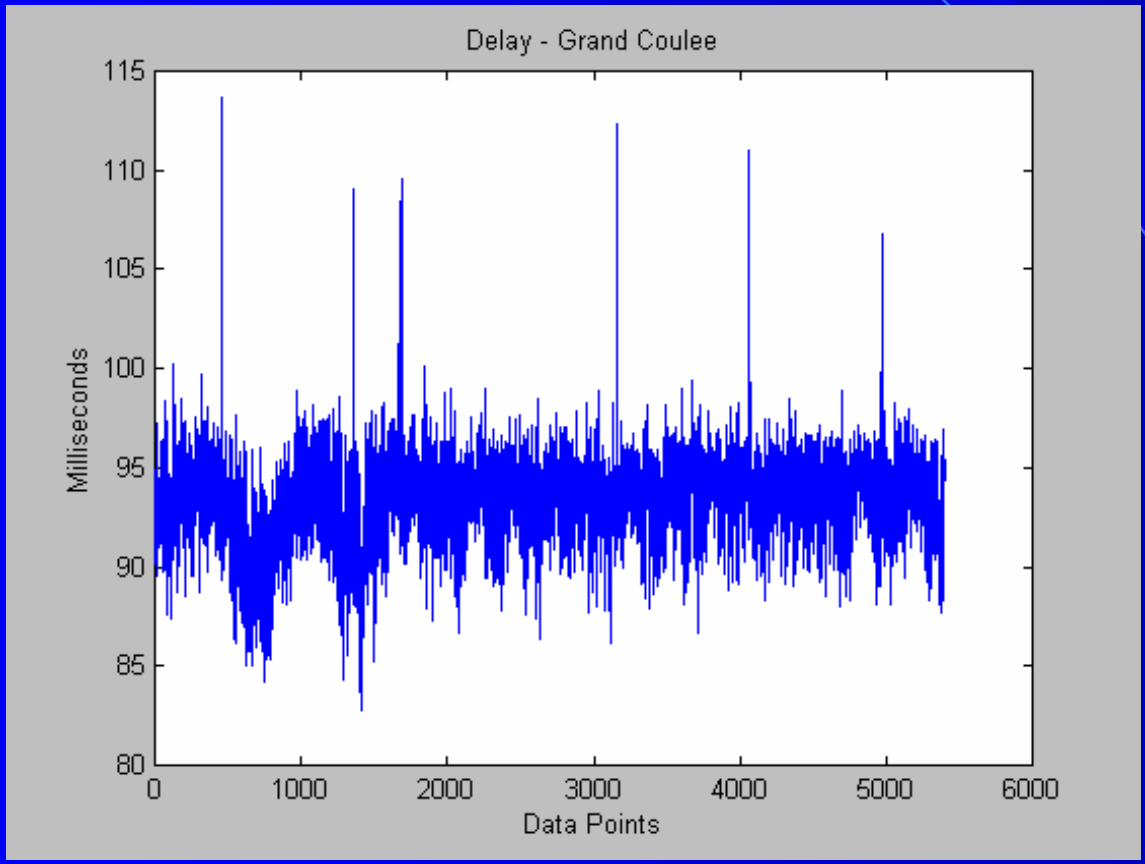
Point on wave data, assumed protocol

Data rate - bytes/sec

Smp/sec	6 Chan	15 Chan	30 Chan
240	3840	5280	7680
720	11520	15840	23040
1000	16000	22000	32000

Latency – delay from PMU to PDC

- Communication time with V.34 analog modem, 300 mile distance



Standards & Protocols

- COMTRADE, IEEE C37.111
  - Widely used for recorded data, particularly DFR data
  - Not applicable for real-time data exchange
- SYNCHROPHASOR
  - IEEE1344-2001 current. Defines:
    - Time synchronization requirements
    - Sampled data method with timetagging
    - Data transmission formats

Standards & Protocols (con't)

- SYNCHROPHASOR
  - IEEE PC37.118 under development. Defines
    - Phasor measurement for AC power signal
      - Allowable measurement error
      - Test conditions
    - Data transmission formats from single phasor or multiple phasor measurement units
    - Allows inclusion of other related data
  - New standard expected to be complete in a year, will replace IEEE 1344
    - Resolves several problems in 1344

Standards & Protocols (con't)

- De-facto standards
  - Widely used in WECC
- PDC Stream
  - Defined for data-concentrator output
  - Same as 37.118 except for some status fields
    - Will be superseded by 37.118
- Disturbance file format (.dst format)
  - Compact, binary format
  - Self extracting, single file format
  - Separate calibration file
    - Helpful for correcting data scales, comparing data

Summary

- Communications determined by type of WAMS
  - Local WAMS records data at measurement site
    - File transfer only
    - Little communication requirement
  - Remote WAMS sends out data in real time
    - Communication critical element
    - Delay important in WAMS used for controls
- Standards important to orderly implementation
  - Need to be understood for successful interfacing
  - Apply to data formats for decoding, recording & analysis

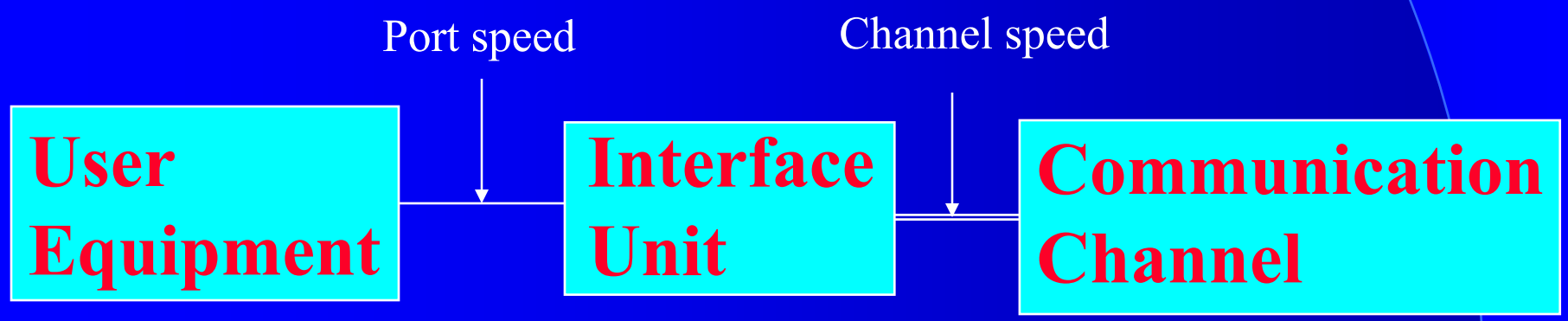
Extra slides

Communication Transport Media

- Analog systems
  - Analog microwave
  - Power Line Carrier with channel system
  - Radio systems - AM, FM
  - Rarely found now in commercial systems
- Digital types
  - Digital Microwave
  - Fiber-optic systems
  - Satellite systems
  - Digital radio systems
  - Internet

Interface and channel speeds

- Interface unit connects terminal system to communication system
- Interface unit port speed may be different than channel
  - Interface usually includes buffering
  - Overall data rate must be within channel capability
  - Eg. Port speed 115 Kbps & channel speed 33.6 Kbps; system needs average rate < 33.6 & buffering big enough for bursts



Bandwidth considerations

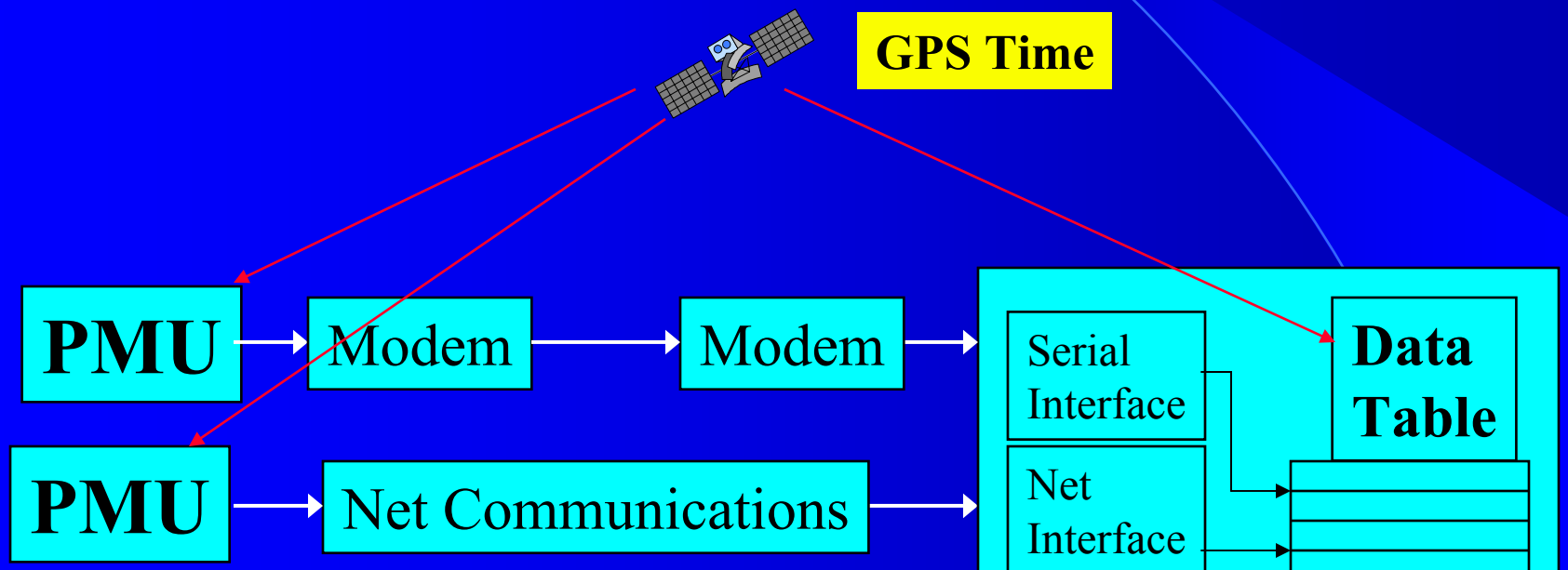
- A given bandwidth can vary
  - Analog modems change speed to adapt to line
    - A 14.4K modem will train down to 12K, 9600, 7200, and 4,800 with high noise
  - Data compression boosts effective bandwidth
- Administration and protocol overheads reduce capacity
  - Every Ethernet packet has a 22 byte preamble
  - Digital channel loading should not exceed about 80% to allow for re-sync

Latency in Phasor Measurements

- Measurement Delay
  - Time from event occurrence until data shows response
  - Depends on algorithm for phasor estimation & sample rate being used
    - Minimum will be the output data rate + measurement window
  - Typically 2-6 cycles at 30 samples/sec
- Transmission and reception delays
  - Time from when data starts to leave PMU until it is buffered in receiving device
  - Effected by data communications type, speed, format, buffering, and distance
    - Minimum effect is usually distance, which is near speed-of-light
  - Measurements range from 1 to 7 cycles

System Latency Measurements

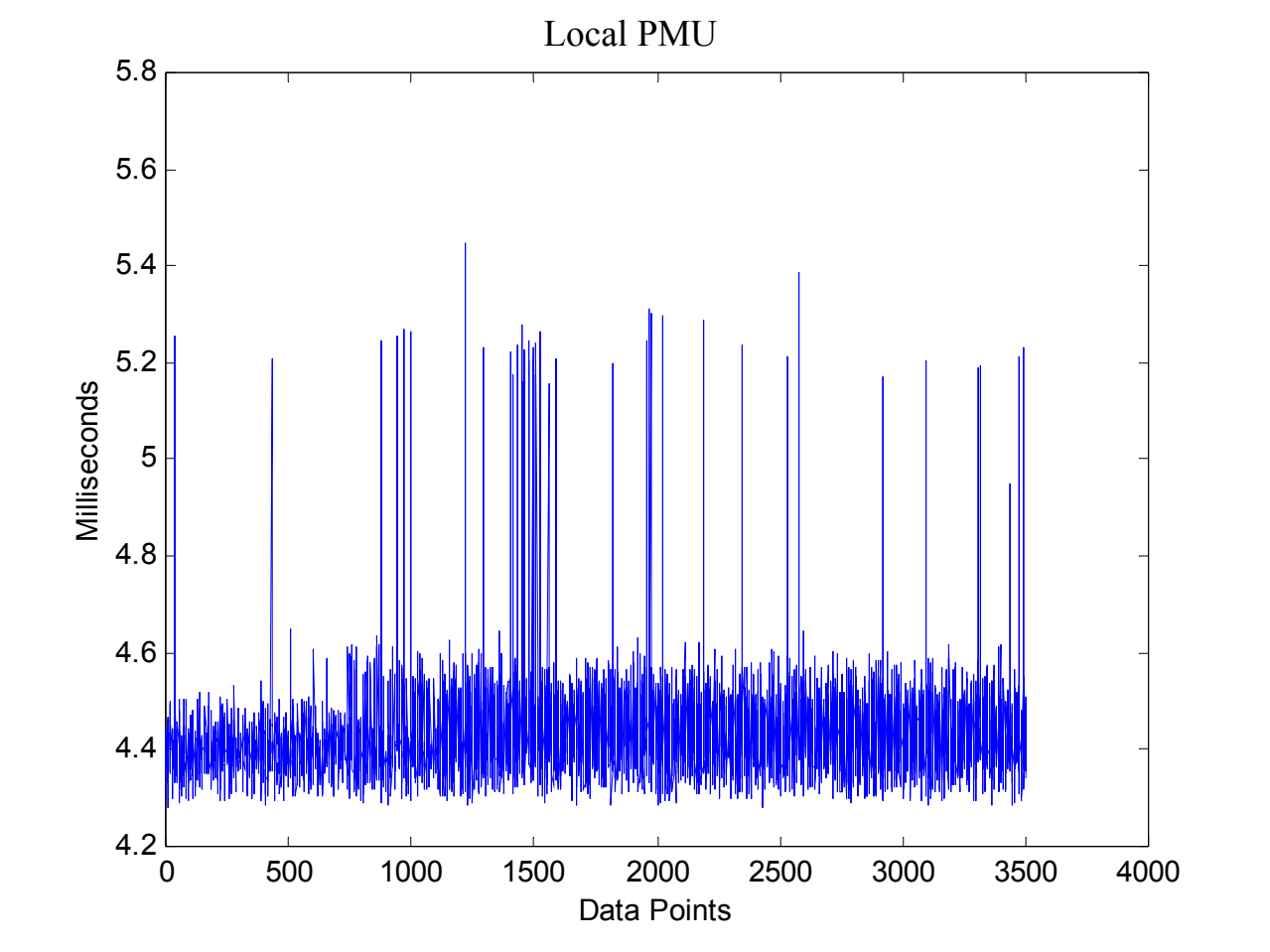
Time from measurement time to table write. Measurement time is time stamp on data (sec & fraction). Delay includes PMU calculation, data transmission, PDC input, & sorting



PDC input & sorting –
~ 3 ms, serial
1-3 ms, network

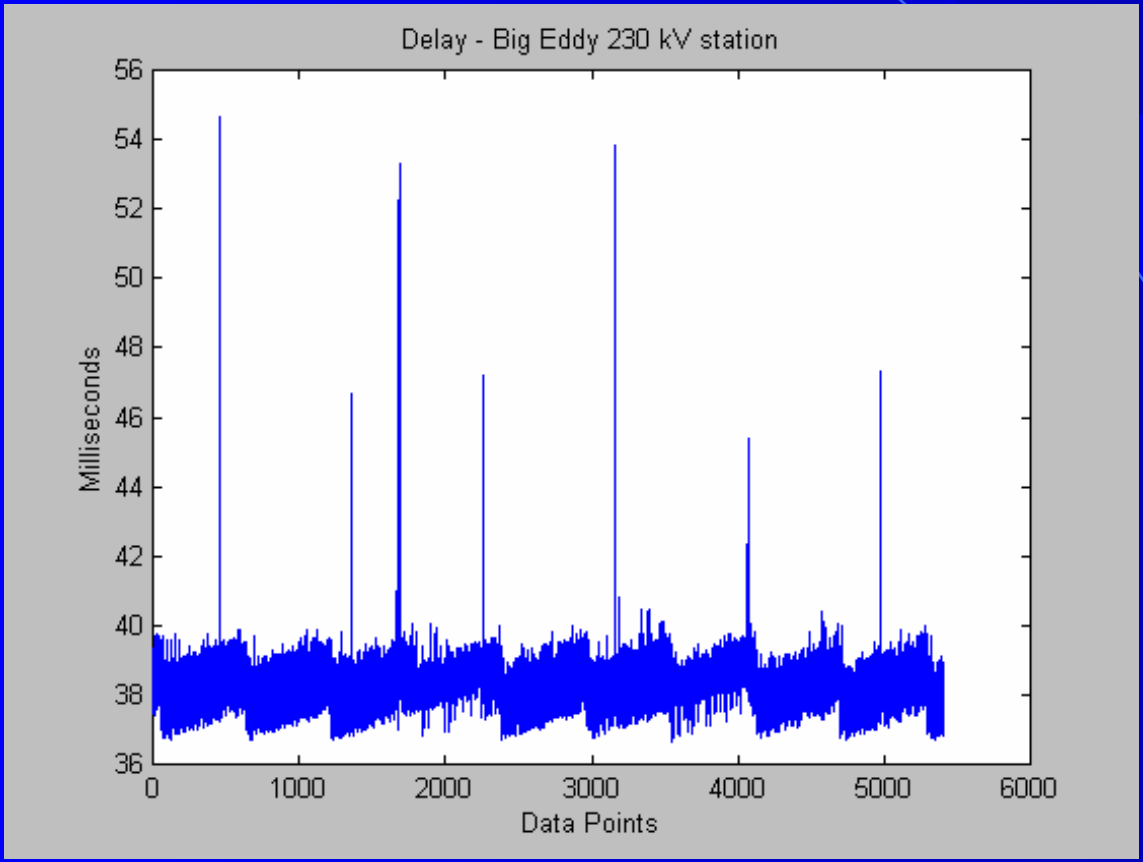
Signal Delay - PMU to PDC

PMU to PDC with local Ethernet connection, TCP/IP protocol



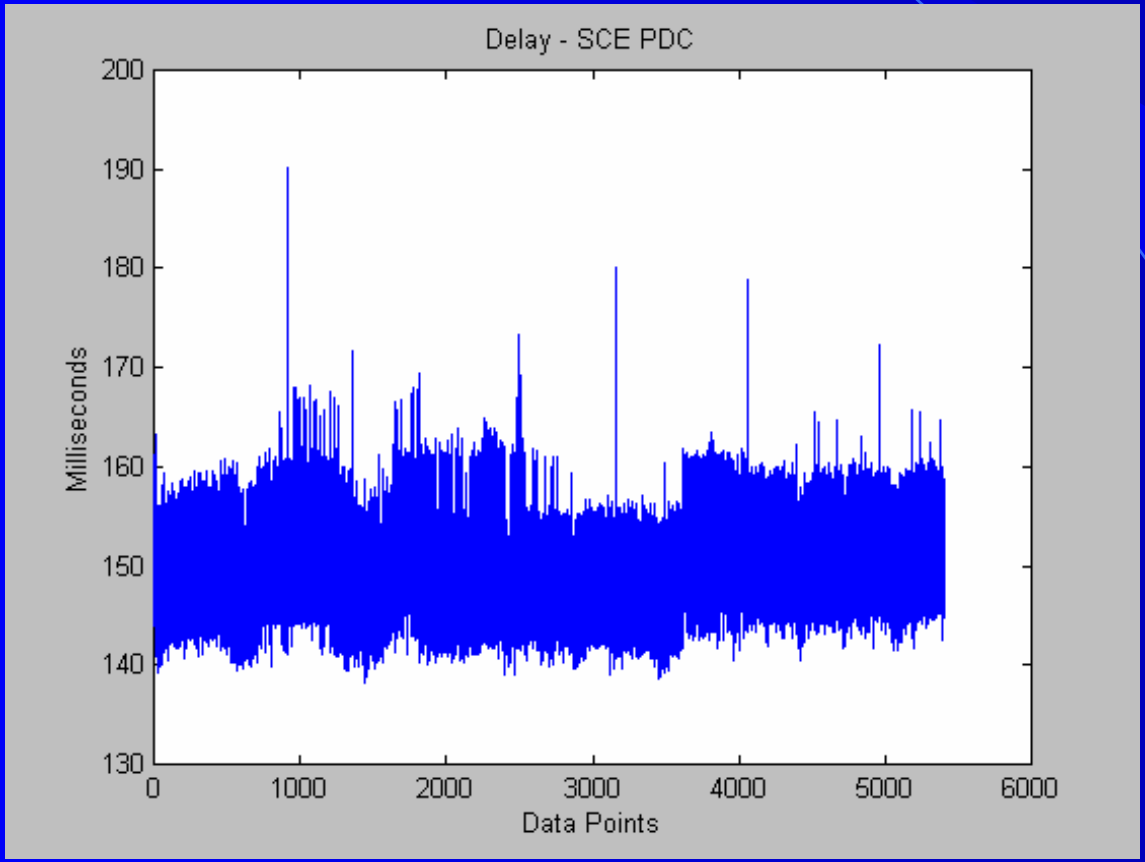
Signal Delay - PMU to PDC

- Communication time with direct fiber link & asynchronous interface



Signal Delay - PDC to PDC

- Communication time from PMU to PDC with fiber link then on to a second PDC with V.34 analog modem

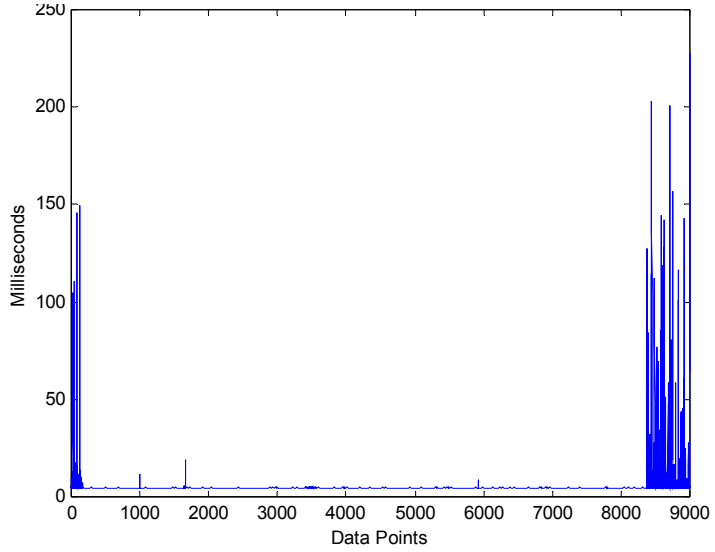


Standards & Protocols (con't)

- IP protocol
  - UDP
    - Fast, minimal overhead, no re-transmission
    - Best for real-time applications
  - TCP
    - A fair amount of processing overhead is required
    - Monitors data exchange, re-send lost packets
      - Data recovery induces delays
    - Best used for applications that are not sensitive to delay – eg. File transfer

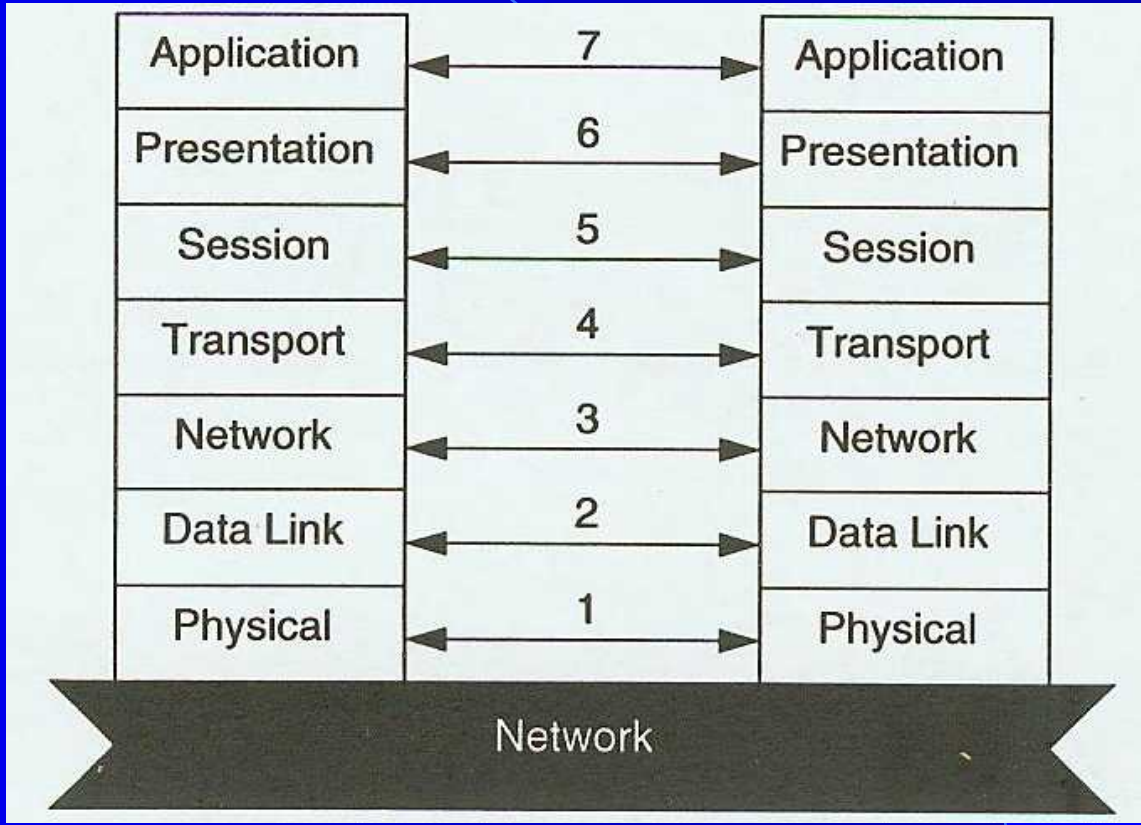
TCP issue:

When network becomes busy, delay increases from 4 ms to 150-200 ms



Delay Summary

- The main communication system distance has little effect on overall delay as it travels near light speed
- Increasing the port speed decreases serializing delay which can be significant
- Modern analog modems are slowest due to coding algorithms, 60 – 100 ms
- Direct digital are faster as there is no coding delay, 20 – 40 ms
- Network is fastest as it also minimizes serializing delay, 4 – 8 ms

OSI communication model

- 7 layer model
  - Can be used to characterize any system
- Various systems group or eliminate layers
- Systems generally follow model