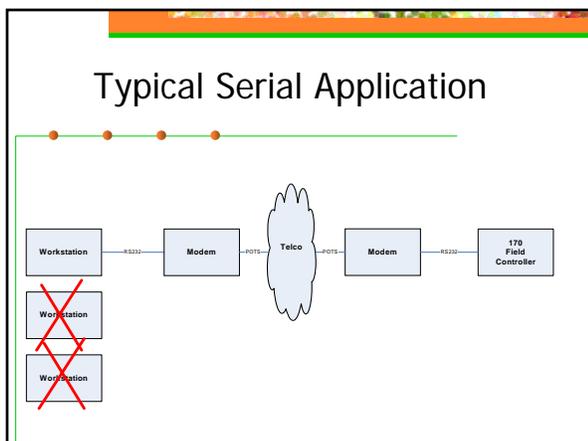
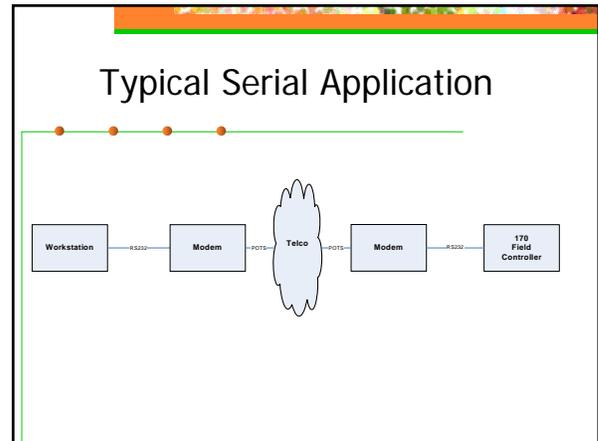


Web Based ITS Field Element Control

Sean.Campbell@dot.ca.gov  
(916) 654-8868

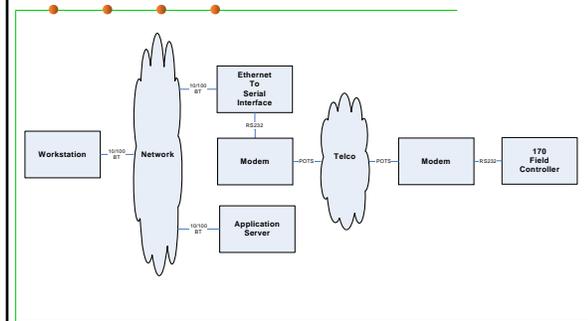
Using a web browser and carefully selected commercially available hardware components, design a system to control a remotely located ITS field element.

- ### Why Would We Do This?
- No more island computers that only have the software installed on a particular machine.
  - Ability to control field elements anywhere
  - Ability to easily share information
  - Low Cost
  - Relatively easy to maintain
  - Retains in-house knowledge

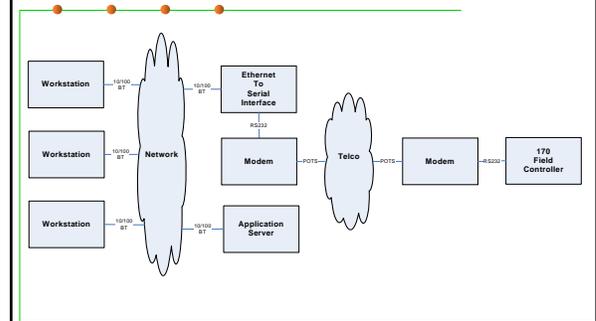


- ### Typical Serial Application
- One or maybe two workstation control
  - Workstation per application
  - Inability to share information / status
  - Workstation hardware limitations
  - Distance limitations
  - Software and operating system

## Typical Network Application



## Typical Network Application



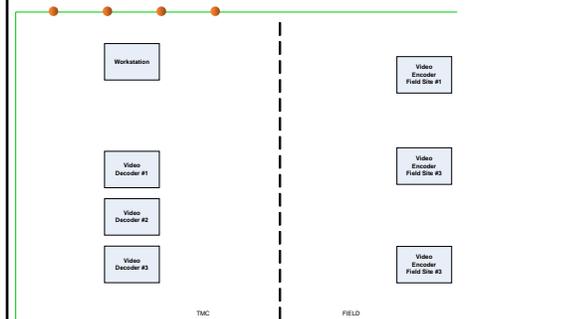
## Typical Network Application

- Multiple workstation control
- Workstation for many applications
- Share information / status via web page
- Limitless hardware possibilities
- No distance limitations

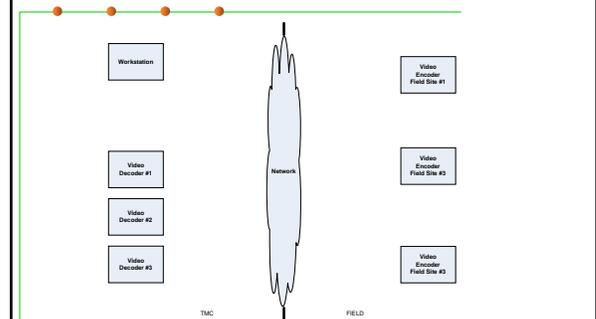
## Atoms and Molecules

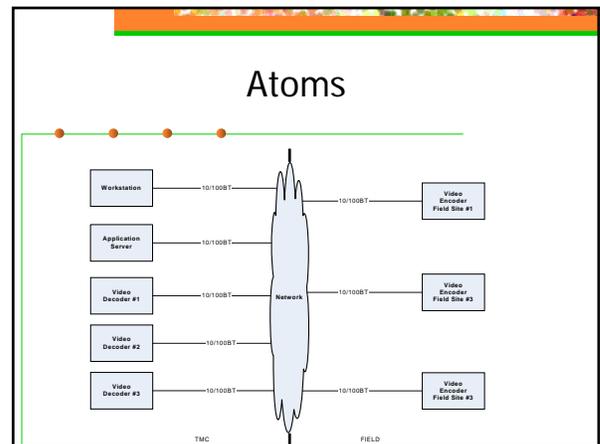
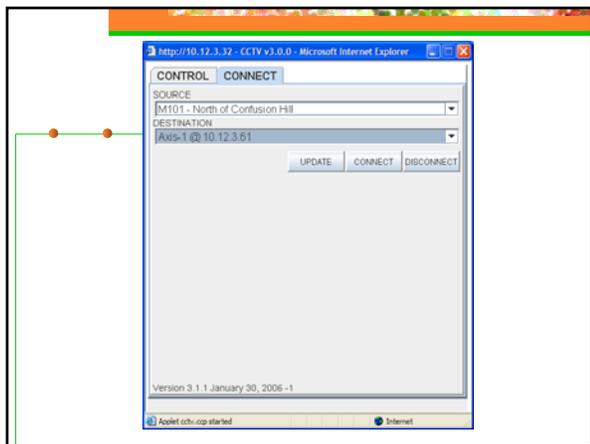
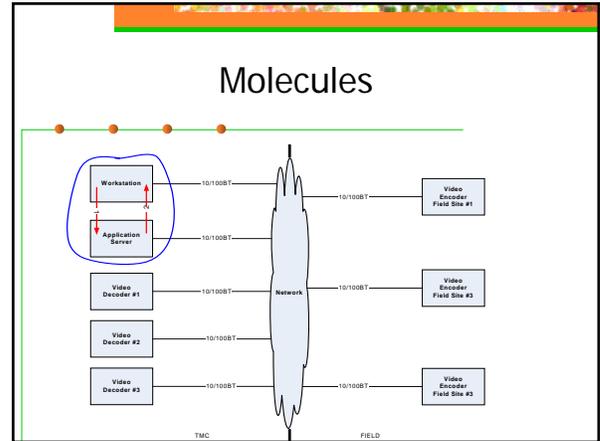
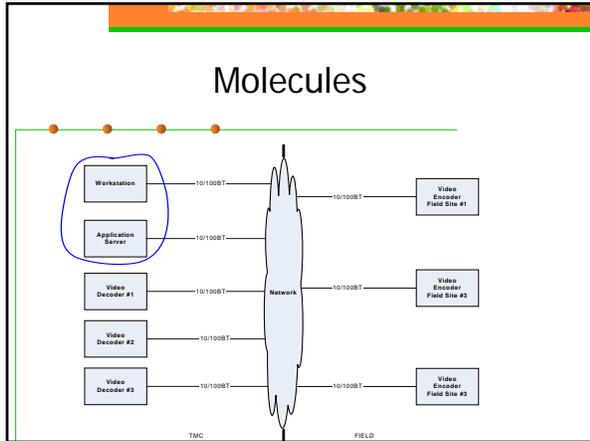
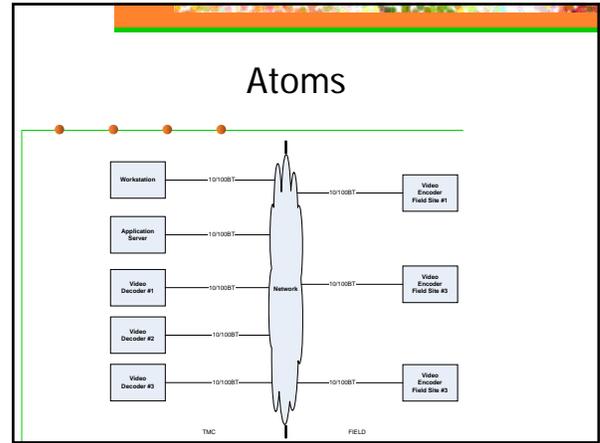
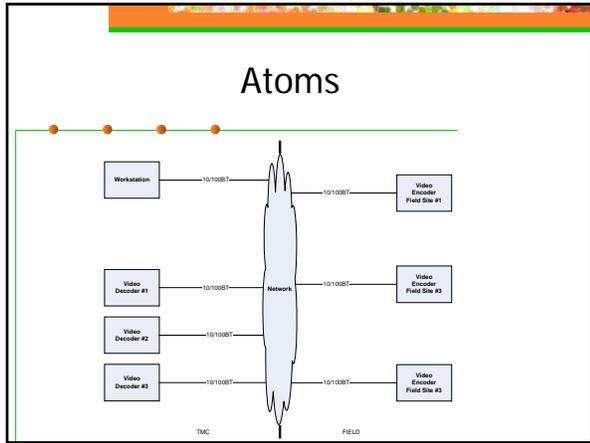
- Think of field elements as Atoms
- Think of TMC equipment as Atoms
- Bond field elements and TMC equipment together to form Molecules
- Virtually bonded together by a network

## Atoms

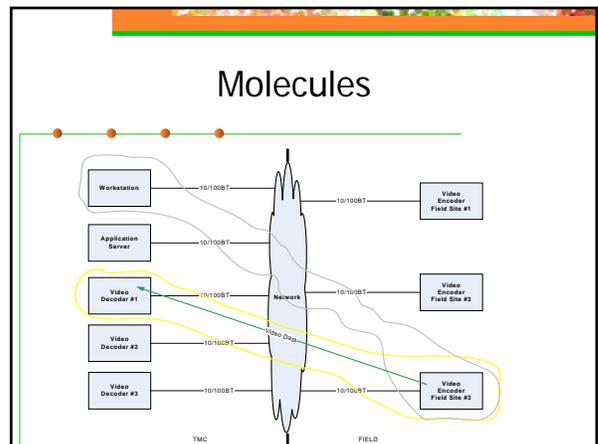
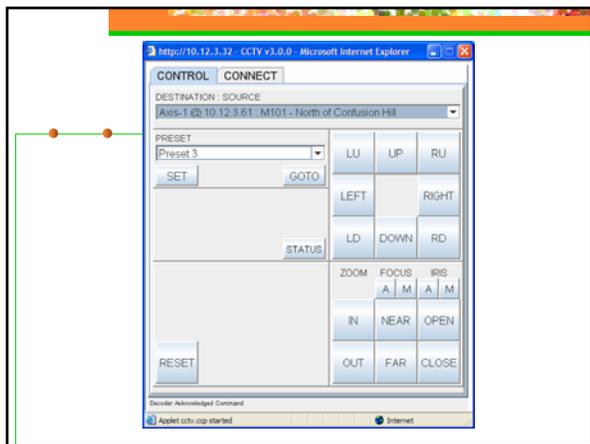
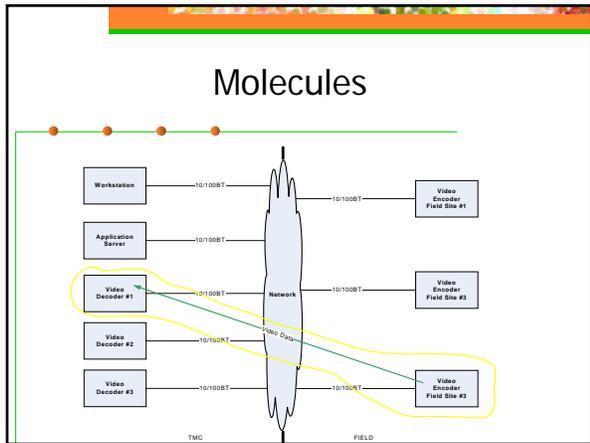
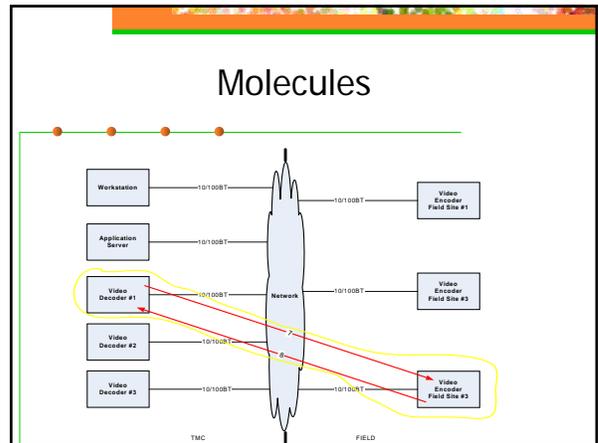
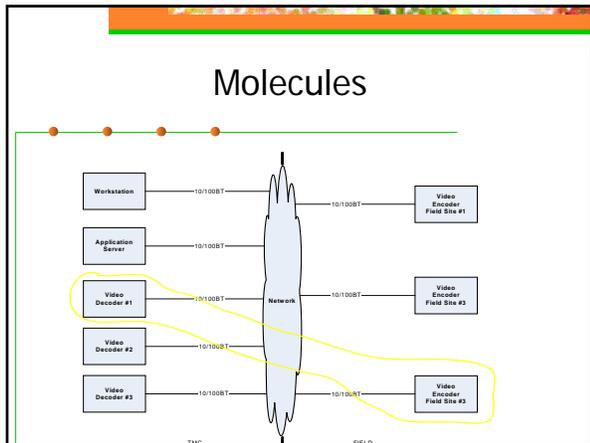


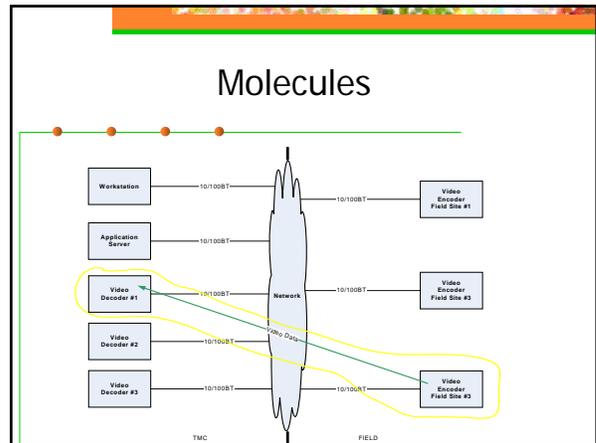
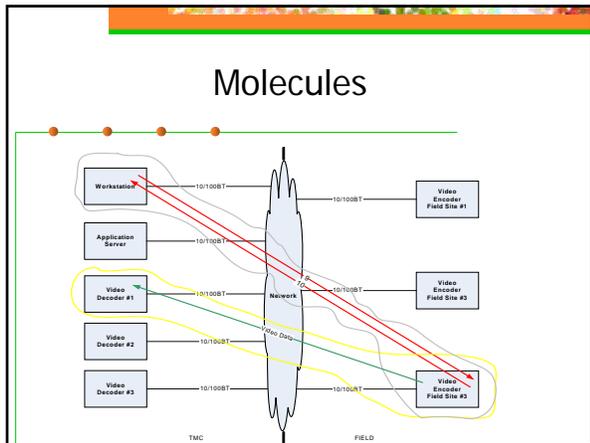
## Atoms











## Engineering

**The Unknown**

As we know,  
 There are known knows.  
 There are things we know we know.  
 We also know  
 There are known unknowns.  
 That is to say  
 We know there are some things  
 We do not know.  
 But there are also unknown unknowns,  
 The ones we don't know  
 We don't know.

Donald Rumsfeld—Feb. 12, 2002, Department of Defense news briefing

## The Known Knowns

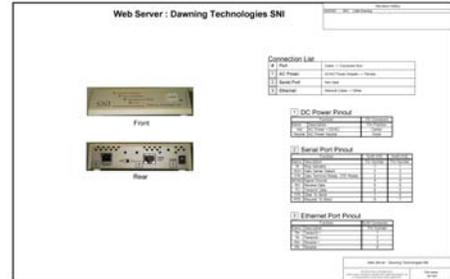
- ## Components Of The System
- **Workstation**
    - Any PIII 400 and up with networking capability
  - **Web Browser**
    - Microsoft Internet Explorer
  - **Plug-In**
    - Sun Java Plug-In
  - **Network**
  - **Equipment**
  - **Application**
- 

- ## Equipment Requirements
- Take care in choosing equipment that has an open or available protocol
  - Choose hardware that will be flexible enough for future change
  - Knowledge of how each piece of hardware fits into system

## Equipment

- Application Server
- Ethernet to Serial Interface
- Field Equipment

## Application Server



## Ethernet to Serial Interface

- Numerous Manufactures / Wide Availability
  - Lantronix
  - Digi
  - Moxa
  - Black Box
- Environmentally Hardened or not
- Wide array of serial protocol
  - RS232
  - RS422
  - RS485

## Ethernet To Serial



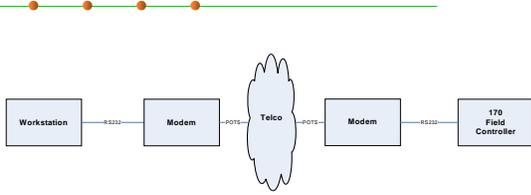
## Field Equipment

- Protocol
- Communication Interfaces
- Features

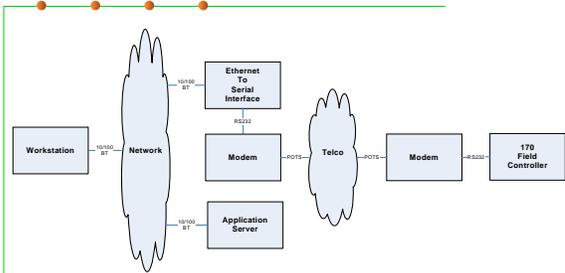
## System Design

- Legacy
- Field Network
- Hybrid

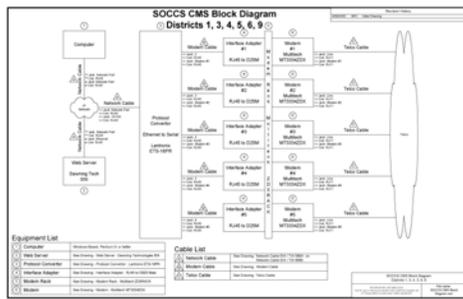
## Legacy System



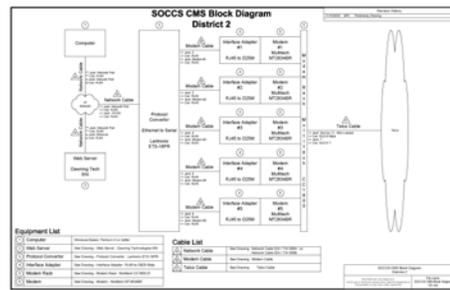
## Legacy System To Network



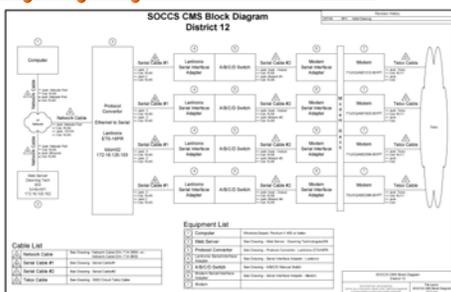
## Legacy System To Network



## Legacy System To Network



## Legacy System To Network



## Field Network

- Network is extended to field
- Multiple devices ride on same communication link

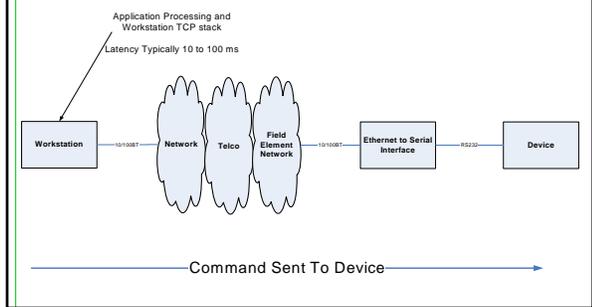


# The Known Unknowns

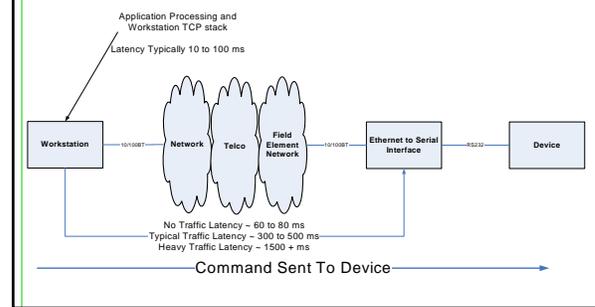
## Latency

- The delay introduced into a system
- Where does it come from?
  - Workstation
  - Network
  - Ethernet To Serial Converter
  - Serial Link
  - Field Device

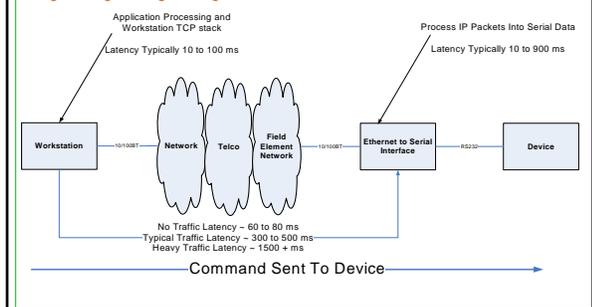
## Latency



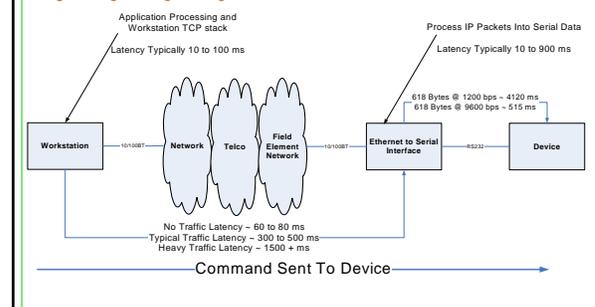
## Latency

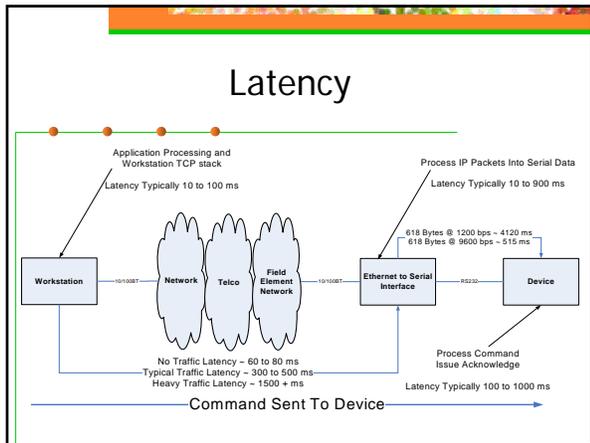


## Latency



## Latency

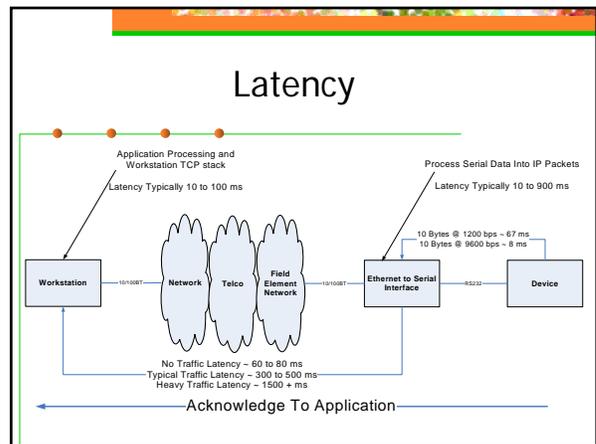
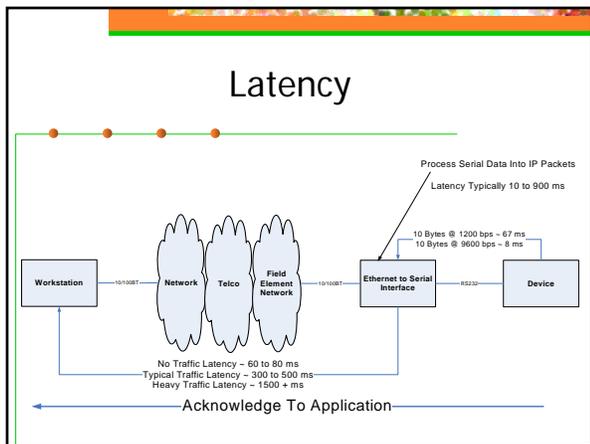
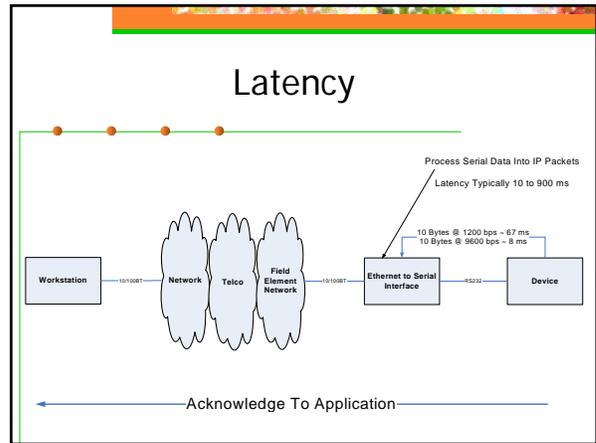
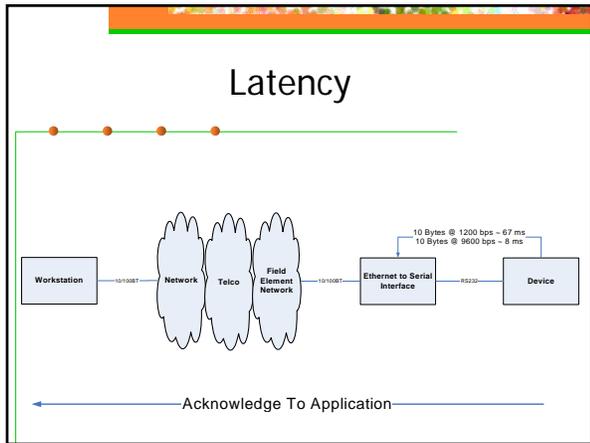




### Latency

**Send Command Latency Totals:**

Workstation / Application	10 to 100 ms
Network	60 to 1500+ ms
Ethernet to Serial Interface	10 to 900 ms
Serial Communication	515 to 4120 ms
Device Processing	100 to 1000 ms
<b>Total, One Way Latency</b>	<b>695 ms to 7620+ ms</b>



## Latency

### Receive Acknowledgement Latency Totals:

Serial Communication	8 to 67 ms
Ethernet to Serial Interface	10 to 900 ms
Network	60 to 1500+ ms
Workstation / Application	10 to 100 ms
Total, One Way Latency	88 ms to 2567+ ms

## Latency

### Roundtrip Totals:

Send Latency	695 to 7620+ ms
Receive Latency	88 to 2567+ ms
Total, Roundtrip	786 ms to 10187+ ms

## Latency

### ■ How To Deal With It

- Make Latency Variables External and User Tunable
  - Connect Timeout – How long to wait before giving up trying to connect to a device
  - Send Timeout – How long to wait before giving up waiting for a response after a command was sent to the device
  - Nagle Algorithm – Pack the data packet full before sending or send as bits and pieces of command in many packets
- Serial Speeds – 628 Bytes ~ 4.2 seconds at 1200bps
  - Increase speed at TMC side to 9600 bps
  - Increase speed at Controller side to 9600 bps
  - Instantly reduces to serial latency to 0.52 seconds

## Latency

### ■ How To Deal With It

- Choose faster Serial / Ethernet device server
- Utilize the Quality of Service (QoS) features on your network

## Modems

- Initialization
- Carrier Speeds
- Retrans

## Field Equipment

- Protocol
- Features





2:39 PM

Location	Date	Time	Client	Application	Message Type	Page Count	Page 1 Message	Page 2 Message	Page 3 Message
CM049-SF200 S B AT KING ST ON RAMP	5/15/2006	13:35	0.0.0.0	TMC	Blank	0.0	Single Stroke	Single Stroke	Single Stroke
CM050-CC 10 E E OF WILLOW AVE UC	5/15/2006	16:34	172.20.1.229	Travel Time	1 Page (Normal)	0.0	Single Stroke	TRAVEL TIME TO RTE 87 7 MIN	Single Stroke
CM051-SOL40 W B E of REDWOOD PKWAY	5/15/2006	9:40	172.20.1.229	Travel Time	1 Page (Normal)	0.0	Single Stroke	TRAVEL TIME TO RTE 4 7 MIN	Single Stroke
CM052-SOL40 E B W OF REDWOOD PKWAY	5/15/2006	15:59	172.20.1.232	TMC	Blank	3.0	Single Stroke	BERKELEY 19 MIN	Single Stroke

CMS Archive List As Of 6/4/2006 At 14:15

Location	Date	Time	Client	Application	Message Type	Page Count	Page 1 Message	Page 2 Message	Page 3 Message
CM012-AM011 N B N OF BROADWAY OC	5/15/2006	15:52	172.20.1.229	Travel Time	1 Page (Normal)	0.0	Single Stroke	TRAVEL TIME TO OAKLAND 34 MIN	Single Stroke
CM011-AM011 S B N OF SIERRA PT KAMP OC	5/15/2006	15:52	172.20.1.229	Travel Time	1 Page (Normal)	0.0	Single Stroke	TRAVEL TIME TO RTE 92 14 MIN	Single Stroke
CM028-SF 101 S B N OF Cass Chavez St.	5/15/2006	15:51	172.20.1.229	Travel Time	1 Page (Normal)	0.0	Single Stroke	TRAVEL TIME TO RFO ADPT 10 MIN	Single Stroke
	5/15/2006							TRAVEL TIME TO	