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***A Multifaceted Approach to
GIS-SCADA Integration***

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Project Objectives

- Integrate GIS with SCADA and meet the following requirements:
 - Integrate one GIS with two SCADA systems
 - Real-time
 - Run as a service
 - Ability to choose subscriptions
 - Archive for history and reports
 - Symbolize GIS based on SCADA values
 - Visualize SCADA events in GIS
 - Reliable, problem notification

Reliance Energy Limited (REL)



- India's foremost private sector electric utility company, incorporated in 1929
- Revenue: \$2.1 billion
- Total assets: \$2.4 billion
- 885 MW capacity
- 5 million customers (currently in GIS)
- Across 4 regions spanning 125,000 sq km (48,000 sq miles)
- And expanding...

The Two Cities

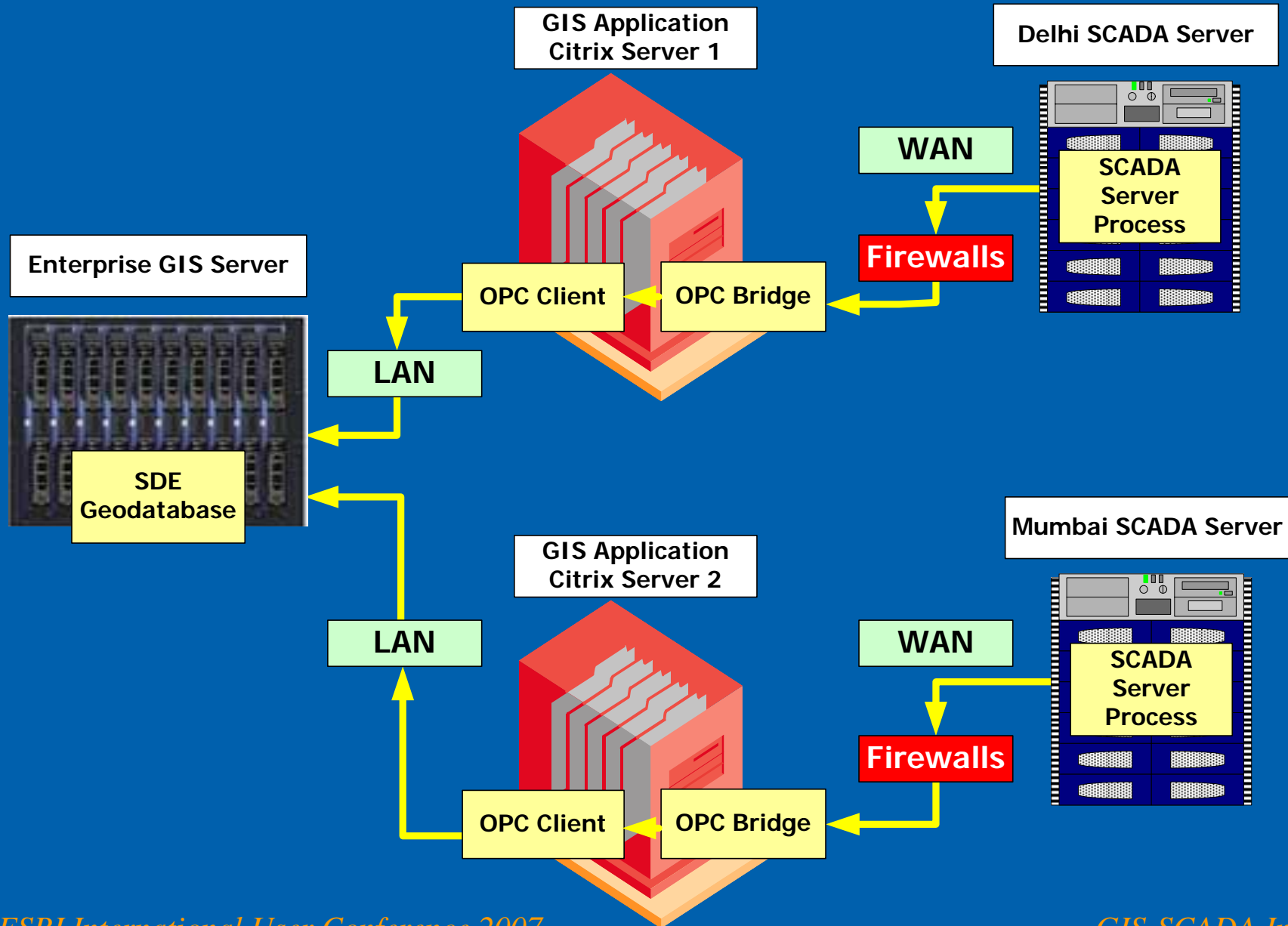
- SCADA was implemented separately in two cities
 - Delhi
 - Mumbai
 - Different utilities
 - Different priorities for the integration



Technical Challenges

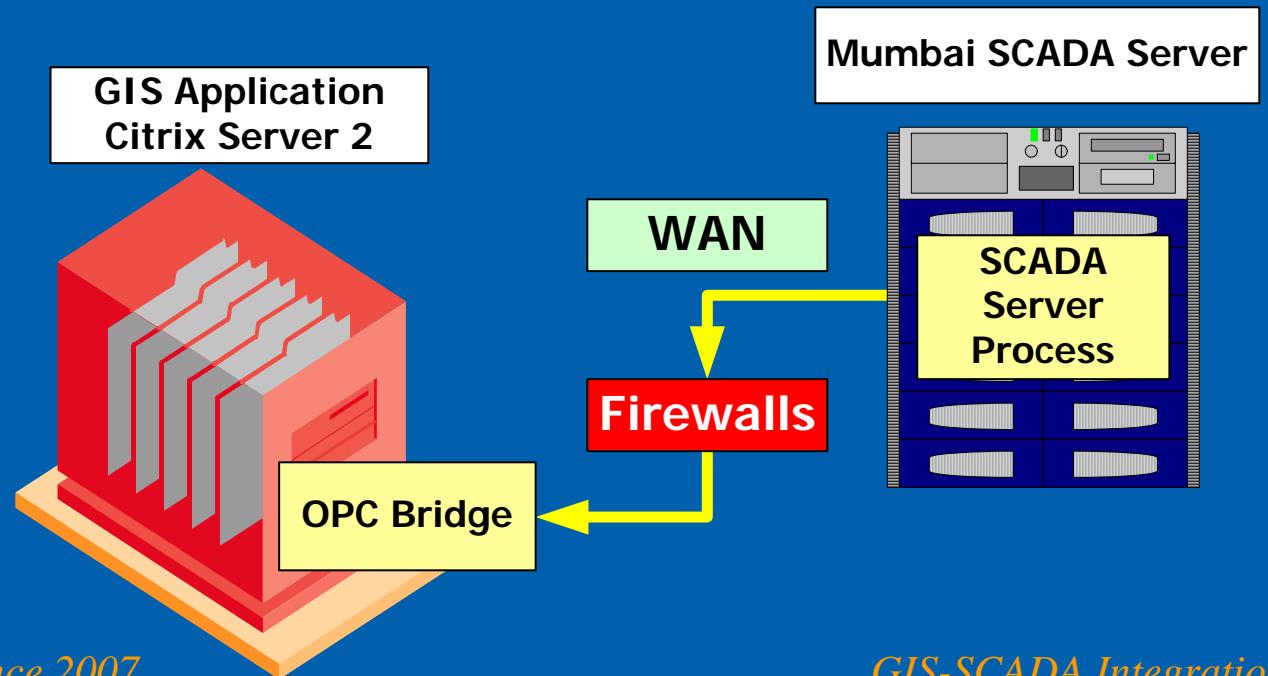
- Differences between Delhi/Mumbai such as...
 - SCADA Nomenclature
 - Switch panels
 - Delhi - left to right text nomenclature
 - Mumbai - unique numbers
 - Monitoring devices
 - Delhi – did not monitor battery sets
 - Mumbai - need to monitor battery sets in substations
 - SCADA deployment
 - Delhi - completed first
 - Mumbai - followed later with different nomenclature
 - Two SCADA systems but a single GIS
 - Different WANs, LANs, Firewalls, network switches
 - And different network administrators!

System Architecture



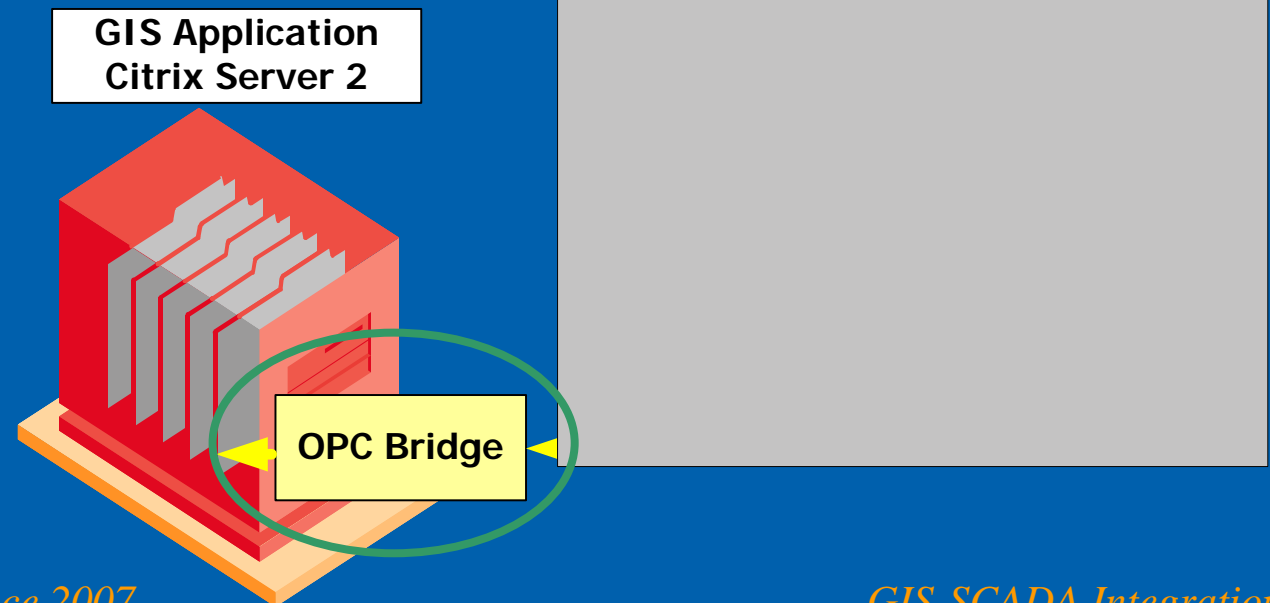
Starting With SCADA

- An event occurs
- SCADA creates a formatted message
- Message passed from SCADA server to the OLE for Process Control (OPC) Bridge on the Citrix server



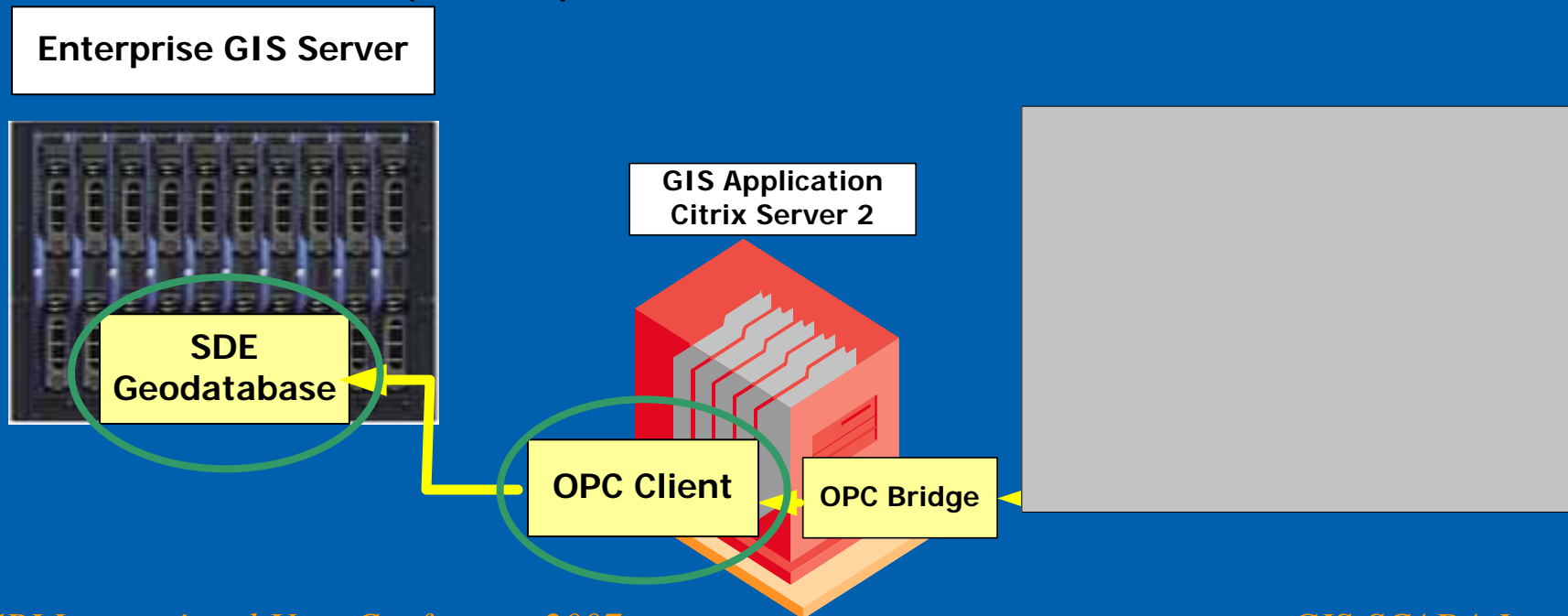
The OLE for Process Control (OPC) Bridge

- Link between Unix SCADA server and Windows Client
- Exposes OPC compliant API
- Publishes events for message delivery to other systems



Real Time - The OPC Client

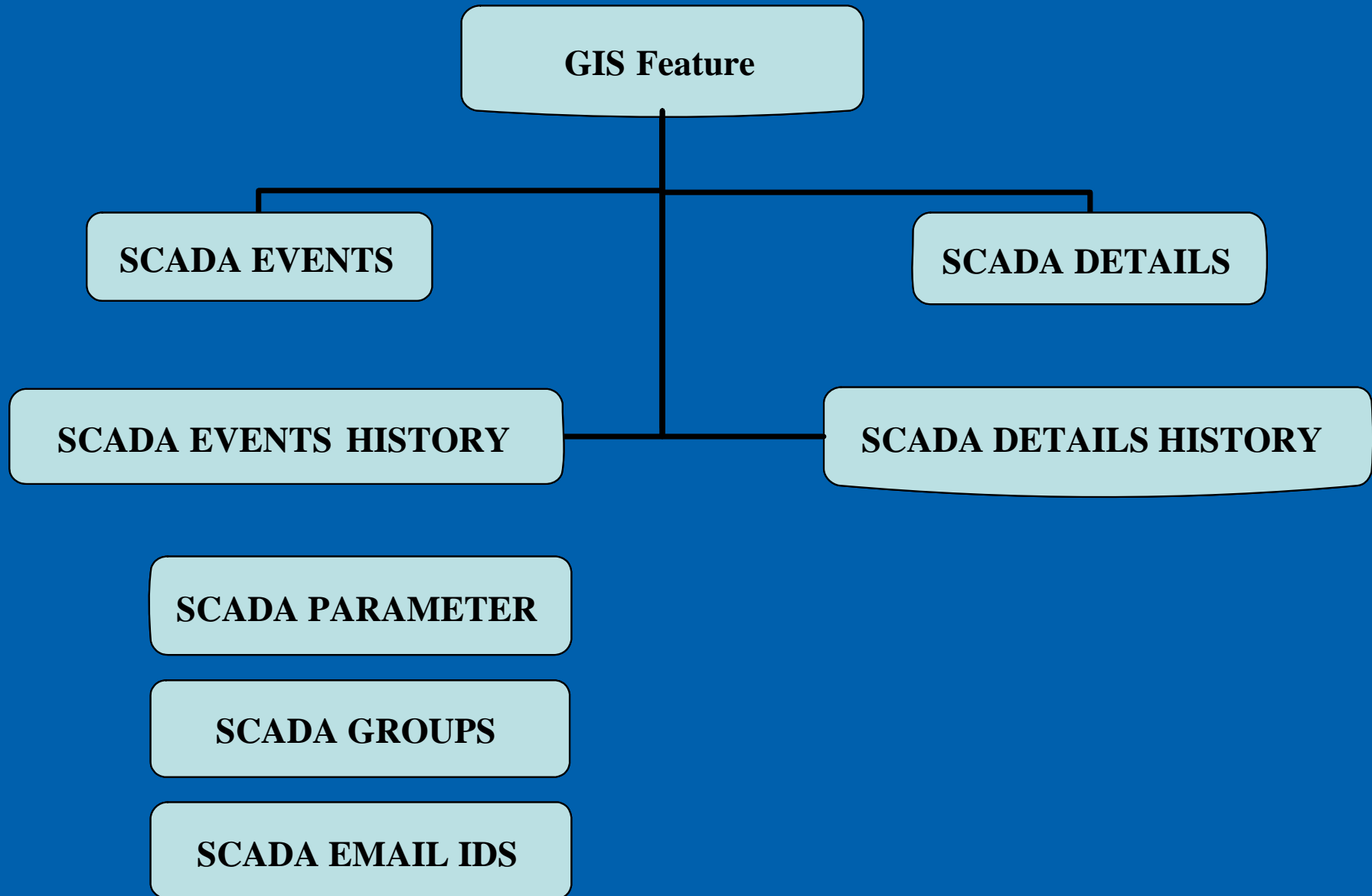
- Windows service - continuously waits for messages from the OPC Bridge
- Asynchronously processes messages
- Stores messages into non-versioned Oracle (SDE) tables



SCADA Subscriptions

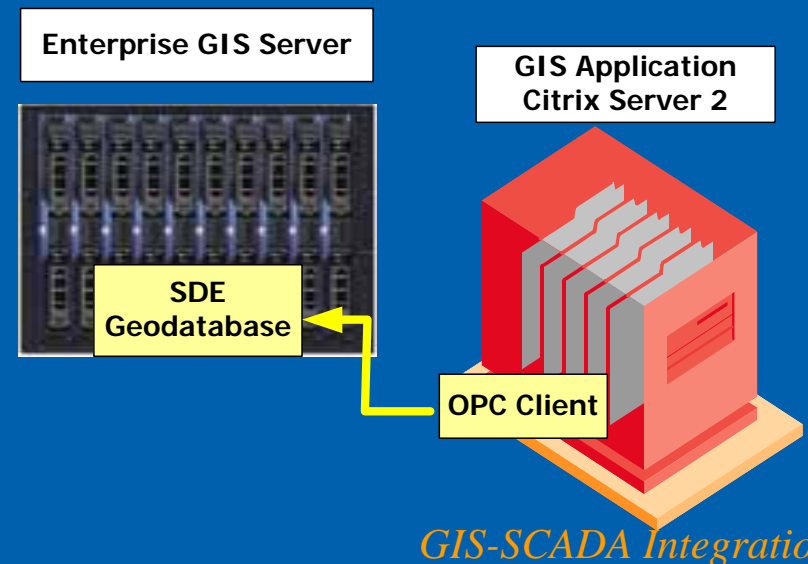
- OPC Client “subscribes” to the OPC Bridge for analog and digital changes
 - Based on threshold values or time interval
 - Analog – a value such as current or voltage
 - Exceeds a configured threshold
 - Digital – such as open/close of switches
 - No threshold – only after time interval
 - Both will be monitored only after time interval

Archiving/Reporting - SCADA Tables

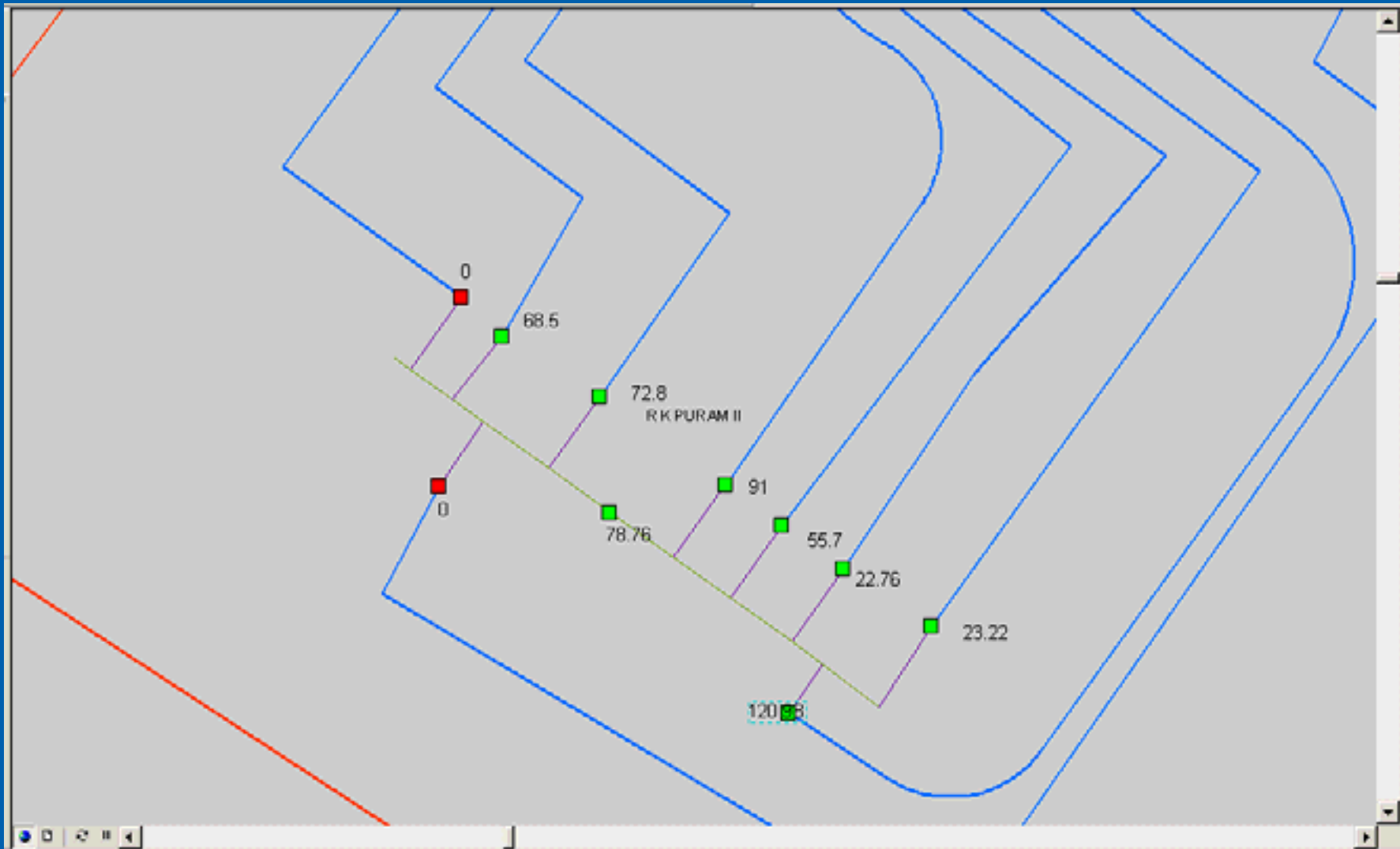


Symbolization – Database Relationships

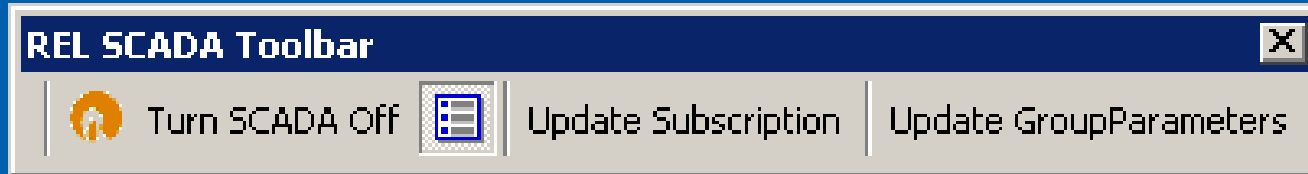
- Tables constantly updated by the OPC Client
- Non-versioned SCADA tables related to corresponding ArcMap Layers through the SCADA_ID
- Features symbolized based on their analog or digital values
 - analog = percent change
 - digital = open or close



Symbolization – Circuit Breakers Opened (red), Closed (green)



SCADA Toolbar



- SCADA (Viewer) on/off
 - Starts and stops the viewer from displaying the SCADA events/messages
- Event viewer
 - Displays the current SCADA events/messages
- Update subscription
 - Assigns/revokes subscriptions of devices
- Update group parameter
 - Updates interval/threshold for receiving messages

Ability To Choose Subscriptions

- Change configuration file or database settings to:
 - Subscribe to new analog/status values
 - Change parameters – thresholds, time interval
- Use tools on toolbar to:
 - Add new devices/electrical assets in the GIS to the subscription
 - Move devices from one subscription to another
 - .NET Remoting

Visualization - SCADA Event Viewer

Digital/Events

SCADA Event/Details Viewer

| BayNumber | FeatureClassNam | Parameter | Value | Quality | TimeStamp |
|-----------------------|-----------------|-----------|----------------|---------|----------------------|
| ALAK 11 NIL GIRI S.ST | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:43:21 PM |
| ALAK 11 LOCAL TRF | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:44:28 PM |
| ALAK 11 S-BLK GK-2 | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:44:38 PM |
| ALAK 11 MANDAKINI S.S | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:44:46 PM |
| ALAK 11 DESH BANDU AP | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:45:02 PM |
| ALAK 11 NRI S/T | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:45:09 PM |
| VSNL 11 CAP BANK1 | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:40:28 PM |
| VSNL 11 7M.MOTH PH-1 | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:41:02 PM |
| VSNL 11 LV1 | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:41:11 PM |
| VSNL 11 9R-BLK GK1 | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:40:57 PM |
| VSNL 11 10NEHRU APPT | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:40:48 PM |
| VSNL 11 BUS COUPLER | CircuitBreaker | AUTO TRIP | AutoTrip Reset | good | 9/25/2006 1:42:53 PM |

Clear Viewer Auto Refresh ArcMap

Analog/Details

SCADA Event/Details Viewer

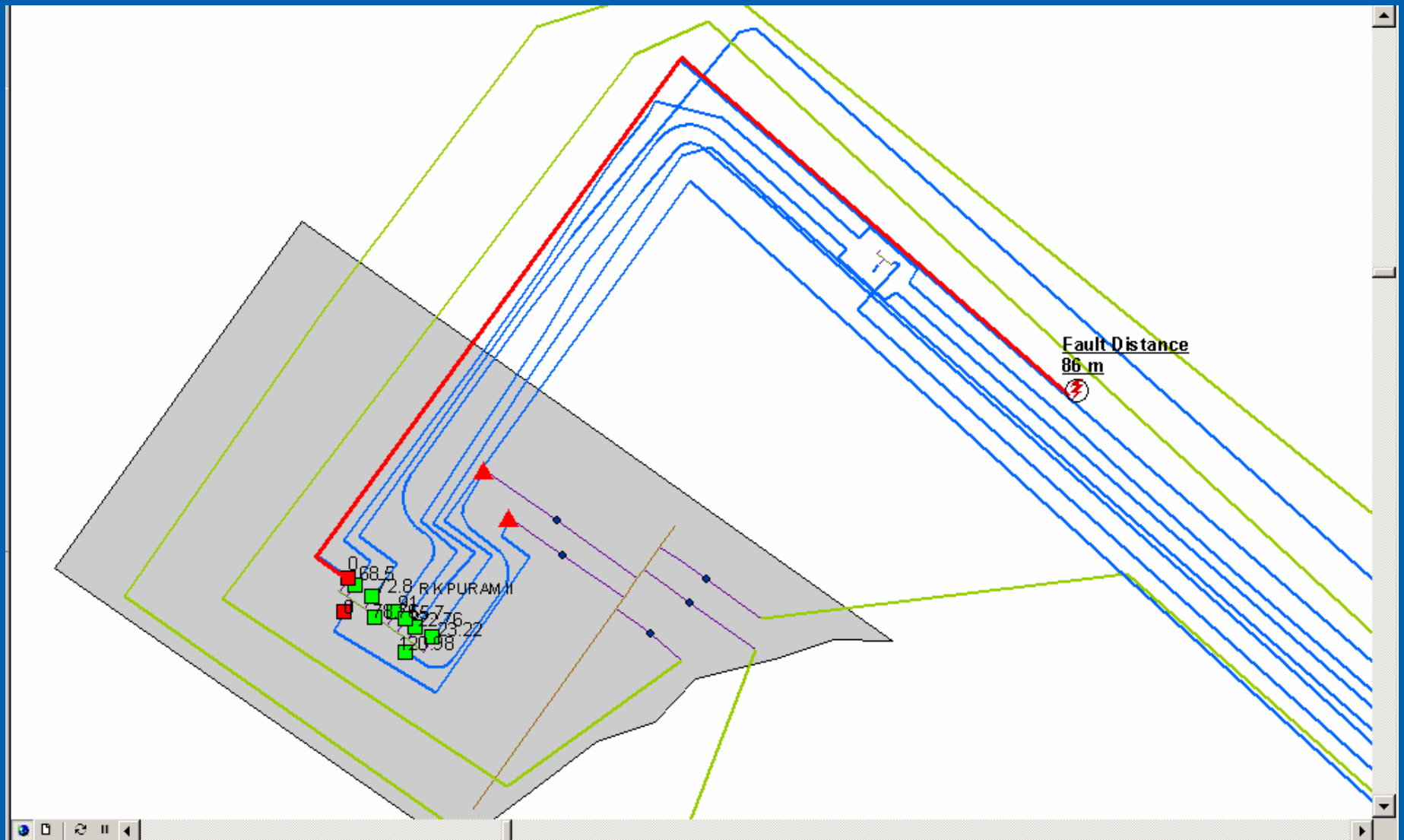
| BayNumber | FeatureClassNam | Parameter | Value | Quality | TimeStamp |
|-----------------------|-----------------|--------------|--------|---------|----------------------|
| VSNL 11 7M.MOTH PH-1 | CircuitBreaker | B_PH CURRENT | 70.76 | good | 9/25/2006 1:46:20 PM |
| VSNL 11 LV2 | CircuitBreaker | B_PH CURRENT | 300.71 | good | 9/25/2006 1:40:10 PM |
| VSNL 11 0EPR CLNY | CircuitBreaker | B_PH CURRENT | 79.71 | good | 9/25/2006 1:46:21 PM |
| VSNL 11 2G-BLK M.MOTH | CircuitBreaker | B_PH CURRENT | 72.51 | good | 9/25/2006 1:46:21 PM |
| VSNL 11 4F-RI K GK1 | CircuitBreaker | R_PH CURRENT | 81.67 | good | 9/25/2006 1:46:20 PM |
| ALAK 33 OKHLA FDR-1 | CircuitBreaker | B_PH CURRENT | 0 | good | 9/25/2006 1:43:34 PM |
| VSNL 11 2G-BLK M.MOTH | CircuitBreaker | B_PH CURRENT | 72.51 | good | 9/25/2006 1:46:21 PM |
| ALAK 33 OKHLA FDR-1 | CircuitBreaker | Y_PH CURRENT | 0 | good | 9/25/2006 1:39:40 PM |
| ALAK 33 M.MOTH T OFF | CircuitBreaker | Y_PH CURRENT | 0 | good | 9/25/2006 1:39:37 PM |
| ALAK 33 OKHLA FDR-2 | CircuitBreaker | Y_PH CURRENT | 197.14 | good | 9/25/2006 1:46:22 PM |
| ALAK 33 HV1 | CircuitBreaker | Y_PH CURRENT | 81.71 | good | 9/25/2006 1:46:26 PM |
| ALAK 33 HV2 | CircuitBreaker | Y_PH CURRENT | 125.84 | good | 9/25/2006 1:46:26 PM |

Clear Viewer Auto Refresh ArcMap

Visualization - Fault Display

- Message about fault received by OPC Client
 - Circuit breaker and distance
- OPC Client passes message to the event viewer in ArcMap
 - Multicasting
- Downstream trace performed from the breaker up to the specific distance
- All affected conductors and devices would be highlighted graphically

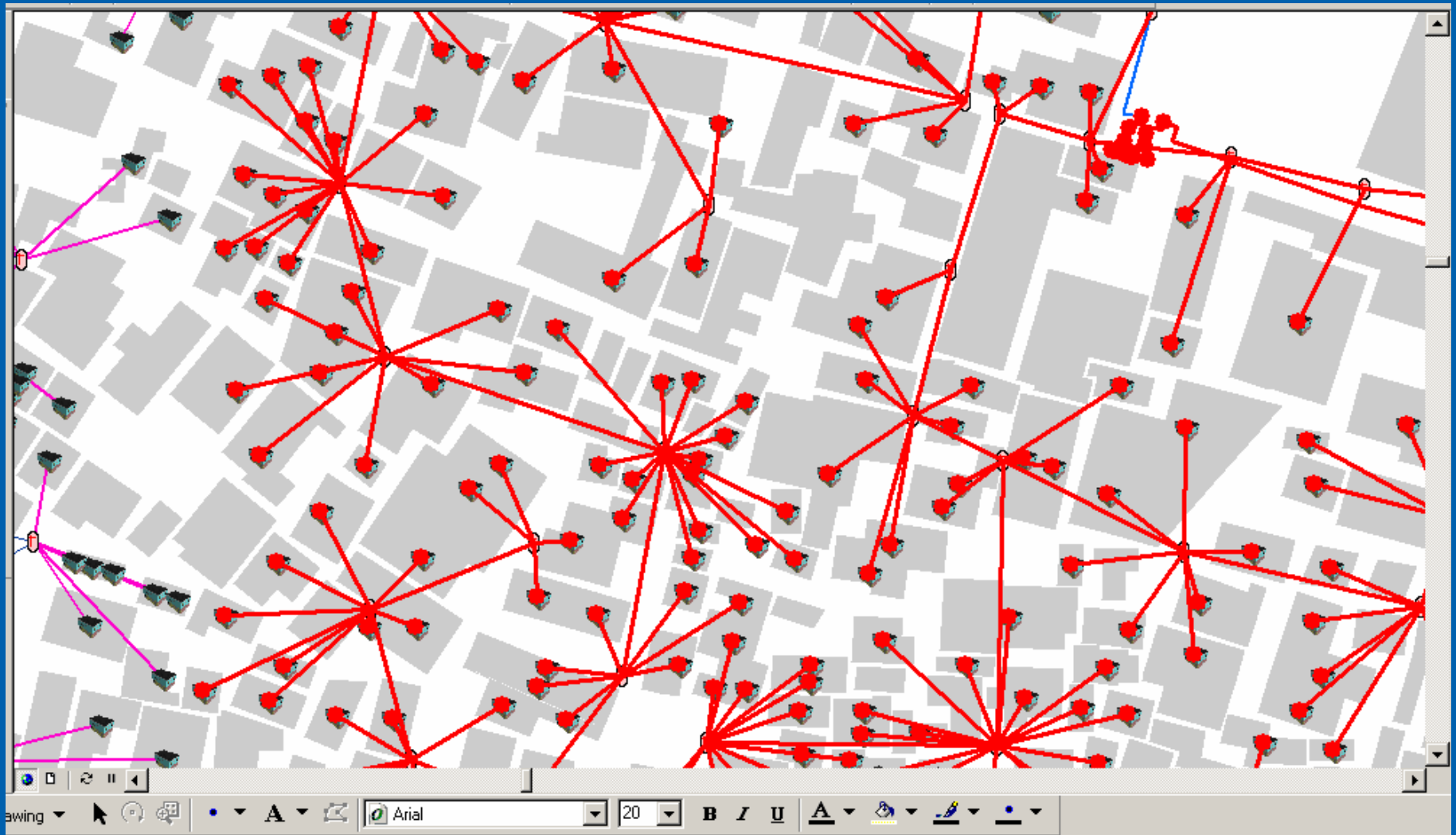
Visualization – Fault, 86m Downstream From Circuit Breaker



Visualization - Feeder Outage

- Message about tripping of a circuit breaker or protective device received from SCADA
- OPC Client passes message to the event viewer in ArcMap
 - Multicasting
- Downstream trace performed to highlight the affected area, electrical devices, service points
- Helps identify consumers within the affected area

Visualization - Area Affected Due To An Outage



Reliability - Severe Outage Performance

- Too many messages could be received due to an outage
 - Windows service was multi-threaded
 - Each message would get a dedicated thread
 - Future - multiple services (clients)
 - Future - message buffer
 - Symbology would change accordingly
 - Auto refresh enabled

Problem Notification - You've Got Mail!

- Email sent if:
 - Certain device tripped more than a threshold number of times
 - Current/voltage value exceeded the threshold
 - An outage occurred
 - Network connectivity breaks
- Complexity because of two cities:
 - Recipient list was separate for the two cities
 - Message in email was different
 - Triggers were different

Deployment - Common Hiccups

- Several problems with NAT – Network Address Translation
- IP address of client not recognized by server because of network switches
- Port would not be open or would close automatically
- Difference in subnet masks caused IP addresses to be ignored by server

Conclusion

- Many technical/non-technical challenges
 - Multiple teams, distance, time difference, work culture differences, network issues
- Met the challenges with patience, an open mind and a drive to make it successful
- The integrated approach of passing messages between systems using services, multi-threading, multicasting was robust and successful
- GIS provided an ideal platform by giving SCADA Location Intelligence
- Technical issues were resolved quickly
- Next...Integrate GIS based OMS with SCADA

Questions?

Further Information: www.opc.org

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