



 **CABLE-TEC**
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***NEW ANALYTIC METHODS FOR DETERMINING
NETWORK PERFORMANCE ISSUES AND
PREDICTING SERVICE DISRUPTIONS IN
CABLE NETWORKS***

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Problem Determination in Cable Networks Is Becoming More Challenging

1. We are increasing network performance demands
 - ▶ Higher orders of modulation
2. The network faces new external sources of interference
 - ▶ Example: High power LTE interference
3. There are fewer expert RF technicians
 - ▶ Retirement has resulted in the loss of critical skills
 - ▶ Very few tech schools/colleges are training new technicians for cable systems
 - Online programs to train new technicians in cable/RF skills only recently launched by SCTE



Current Tools And Their Challenges Meeting The Performance Resolution Goals

Current tools are focused on data collection and reporting

- ▶ Gather tons of data; but virtually no cross-correlation or interpretation of data

Data interpretation and problem identification is dependent upon highly-skilled personnel

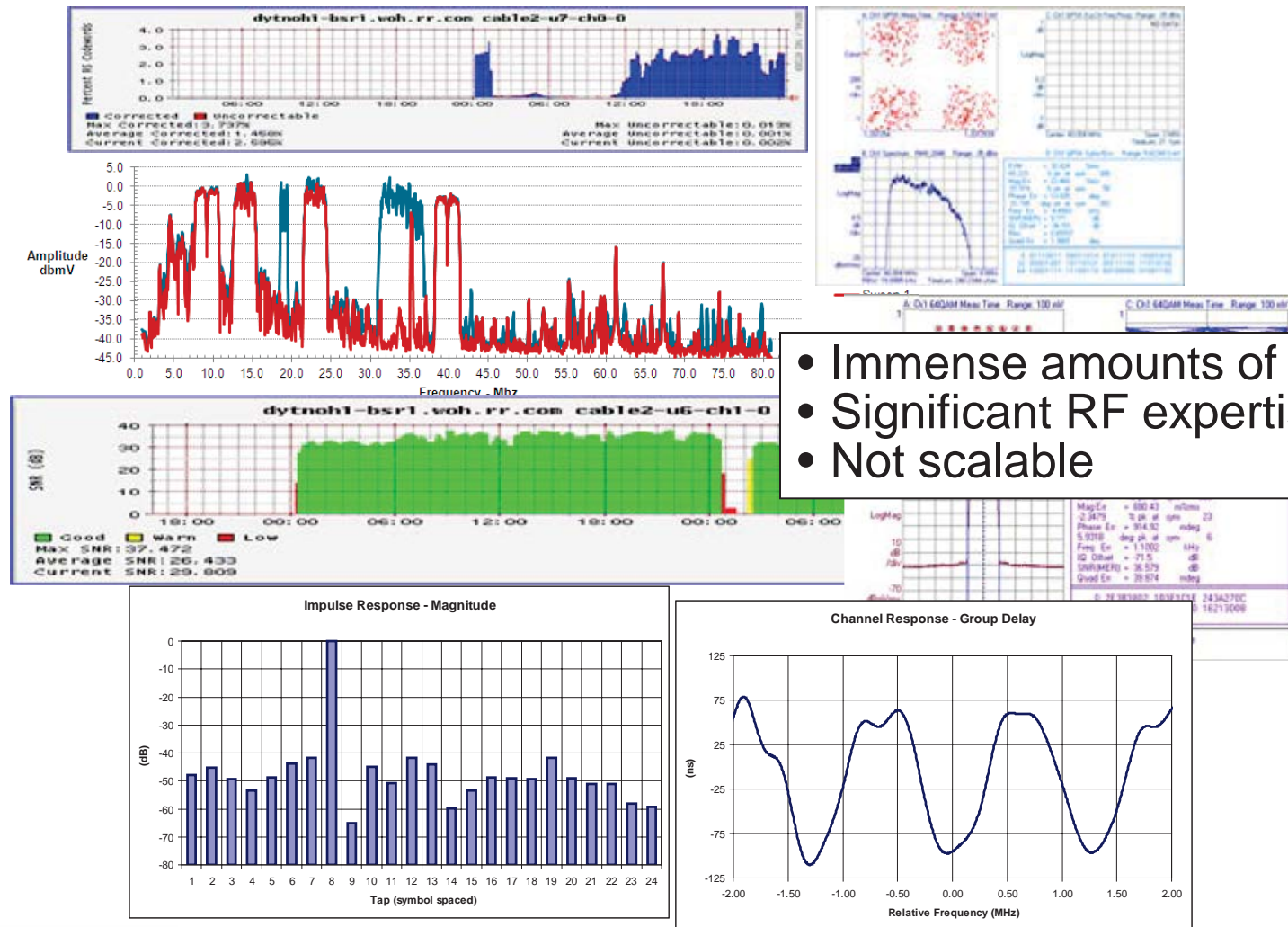
- ▶ Requires RF engineers/RF technicians to interpret data
- ▶ Relies on expert to “connect the dots” on disparate information

No easy means to correlate data to actual customer addresses and equipment locations

- ▶ Data not correlated to network maps nor to customer address databases



Today's Tools



- Immense amounts of raw data
- Significant RF expertise required
- Not scalable



Definitions:

Proactive maintenance: *The concept of finding a potential problem and correcting it before it is service-affecting*

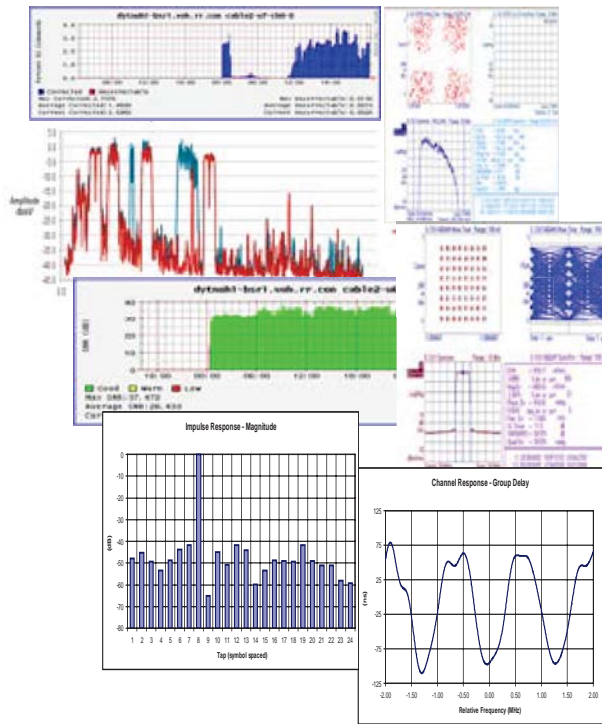
- ▶ Contrast to: “Finding an existing problem before a customer reports it”

Analytics: *The method of logical analysis*

- ▶ Merriam Webster Dictionary



Goals of a Network Analytics Solution



Network Analytics Solution



- Immense amounts of raw data
- Significant RF expertise required
- Not scalable

- Root cause analysis
- Pinpoint fault origination
- Intuitive and scalable visualization

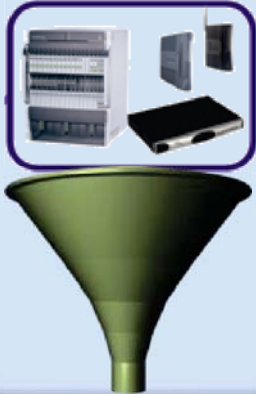
Goals For a Network Analytics Solution

1. Selectively view the network with adjustable granularity
 - To individual street and individual customer level including geo coordinates
2. Graphically display via color code, the status of every service area, device and customer
 - Including associated measured data and performance
3. Simple visual means to determine network status and visually map location of all existing and impending problems
4. Identify the location of each fault, in addition to and separate of the customer locations impacted by the fault
 - Provide a ranking of potential fault causes
5. Ability to set variable thresholds on various defects and performance parameters
6. Provide alarm correlation as a means of prioritizing problems and managing the level of alarms
 - Values may be different at initial implementation versus after network performance is stabilized



Example System Functional Characteristics

CMTSs and CPE



1. Collect data

- CMTS and DOCSIS CPE MIBs
- Time & frequency domain RF parameters
- Network topology data



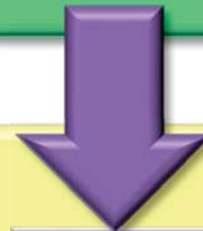
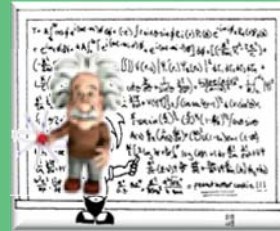
2. Phase 1 Analysis

- Process the received signal & transmit signal data
- Map to network topology



3. Phase 2 Analysis

- Solve a series of equations based on the inter-dependent relationships of the parameters



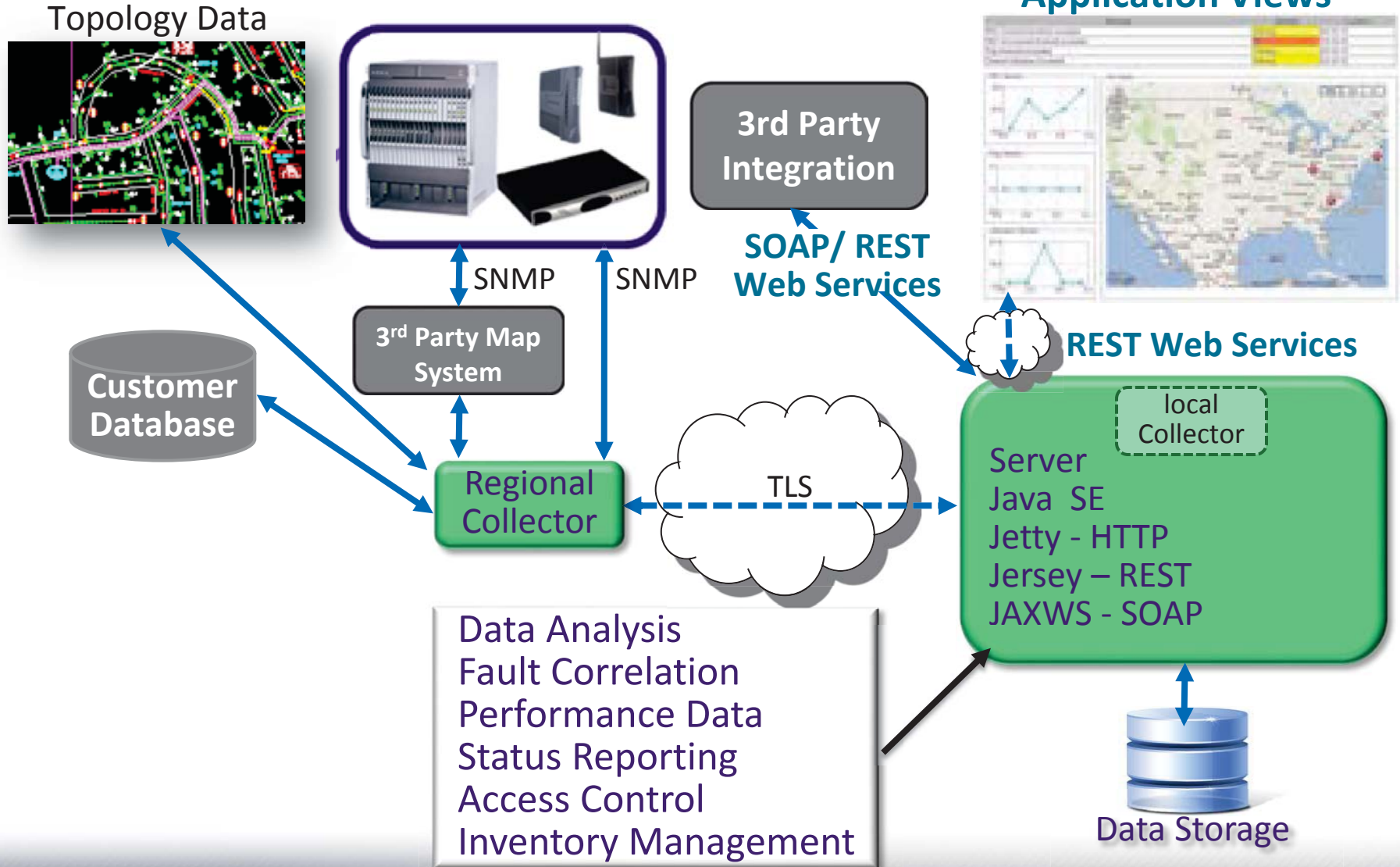
4. Display Results and Detailed Data

- Map/topology based repair recommendations
- Network wide alarm summary
- Detailed data reports & trouble shooting tools



Example Analytics System Architecture

Application Views



Example Use Case

Provide NOC operators network-wide visibility

The screenshot displays a web-based network monitoring interface. At the top, a browser window shows the URL '10.13.218.28:8080/rfMonitor/'. Below the browser, there's a 'Preferences' bar and a 'Logout' button. The main area is a map of the United States with various cities and states labeled. Several red circular markers with numbers inside are scattered across the map, indicating alarm clusters. A purple callout bubble points to a cluster in the Pacific Northwest with the text 'Zoom to more detail'. Another purple callout bubble points to a cluster in the Midwest with the text 'Real Time Alarm Clustering'. Below the map, there's a table titled 'Active Alarms' with columns for 'Active Issues Count', 'Unreachable Modems', 'Total Service-Affected Modems', 'Non-Service-Affected Modems', and 'Active Issues'. A purple callout bubble points to the first row of the table with the text 'Top Network Alarms'.

Zoom to more detail

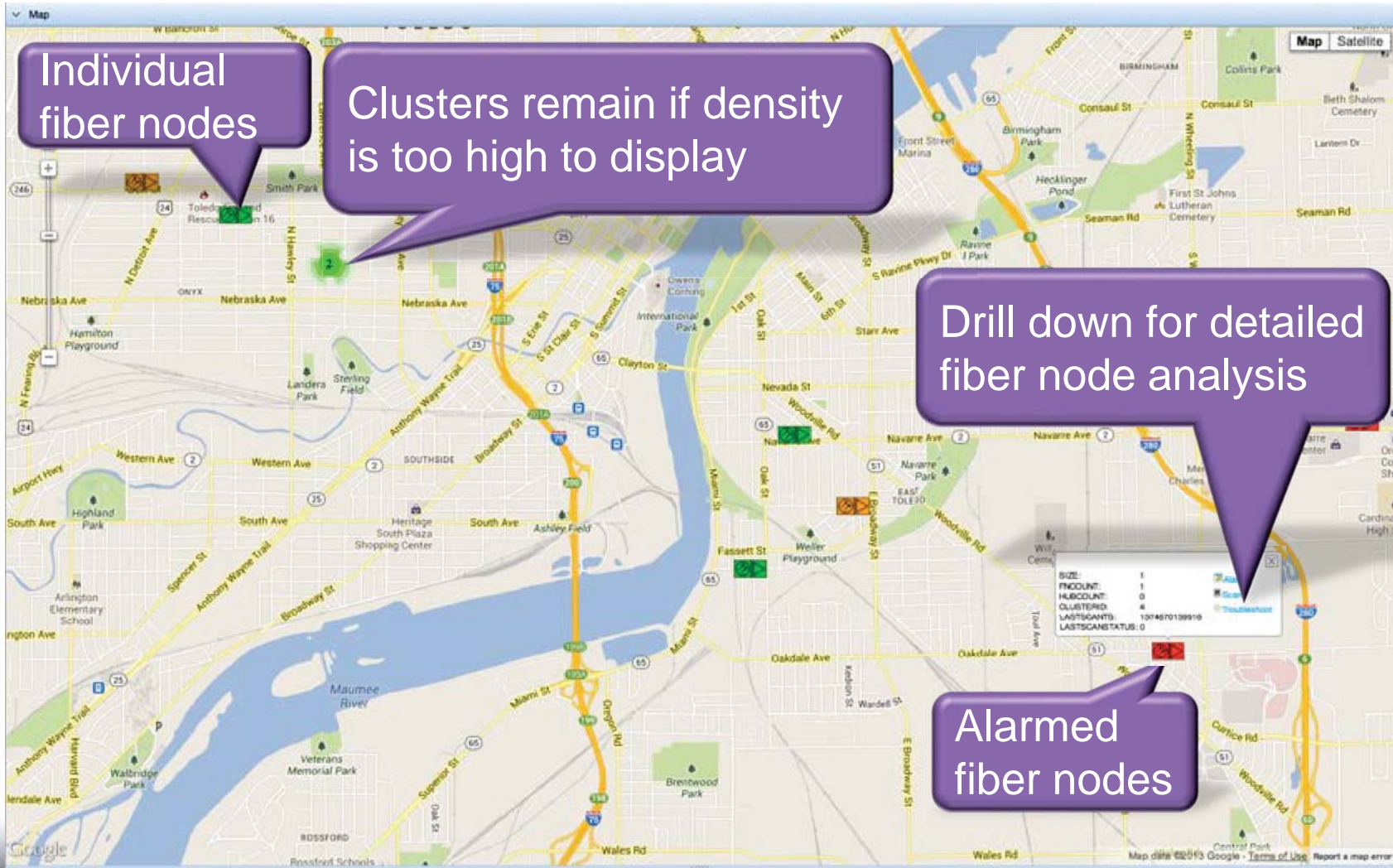
Real Time Alarm Clustering

Top Network Alarms

Active Issues Count	Unreachable Modems	Total Service-Affected Modems	Non-Service-Affected Modems	Active Issues
1	0	0	0	1 (Downstream Power)
3	0	0	0	3 (Upstream Power)
8	0	0	0	8 (Upstream Power)
5	0	0	0	5 (Upstream Power)
5	0	0	0	5 (Upstream Power)
4	0	0	0	4 (Upstream Power)
4	0	0	0	4 (Upstream Power)
2	0	0	0	2 (Upstream Power)

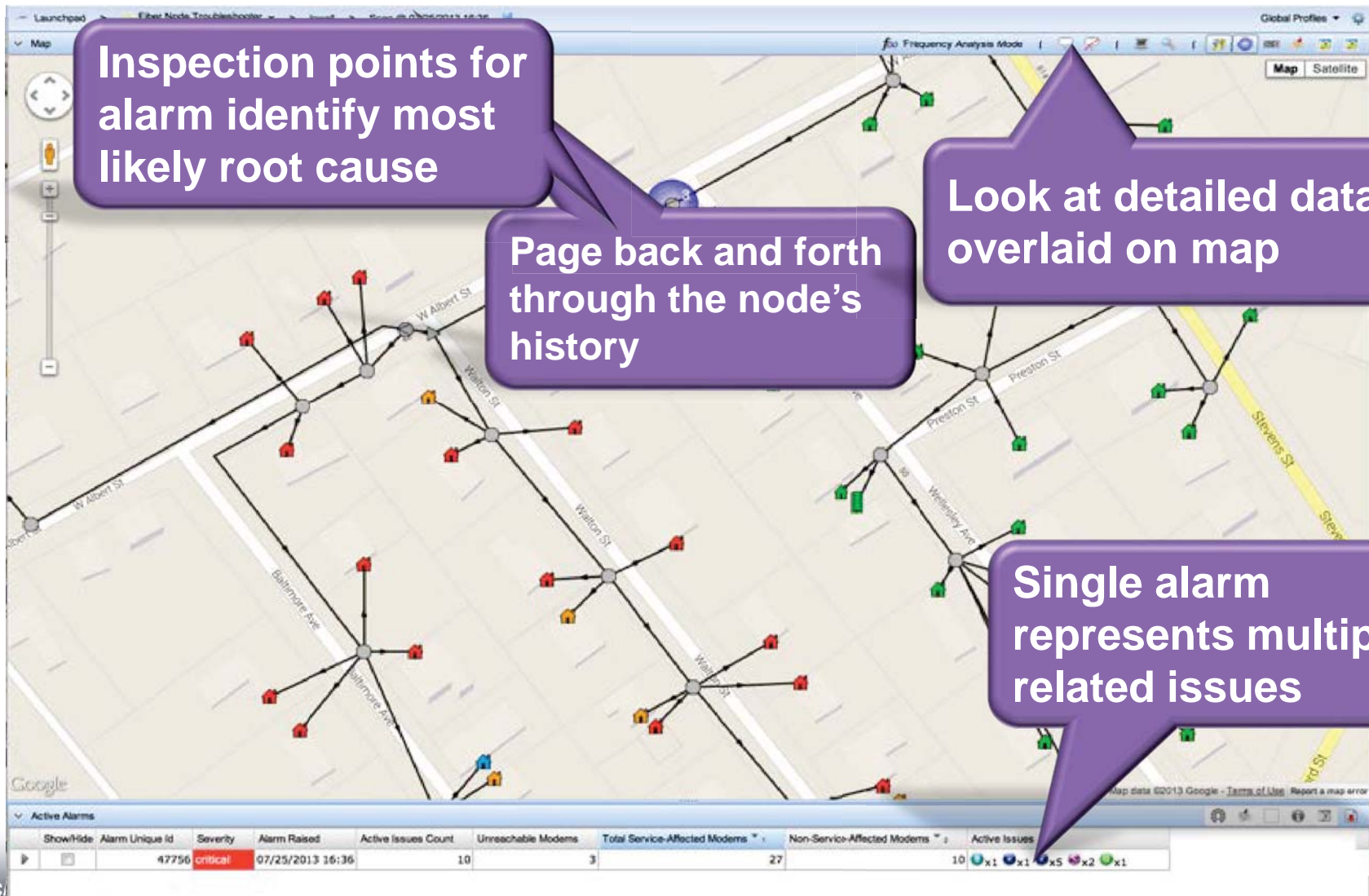
Example Use Case

Zoom in for more detail



Example Use Case

Empower technicians and field engineers



Example Use Case

Select alarm to isolate view in map

Show	Alarm Unique Id	Severity	Alarm Raised	Active Issues Count	Unreachable Modems	Total Service-Affected Modems *	Non-Service-Affected Modems *	Active Issues
	47756	critical	07/25/2013 16:36	10	3	27		10 x1 x1 x5 x2 x1

Example Use Case



Example Use Case

Each alarm can be expanded to see detailed issues

Each per frequency issue rolled up across frequency

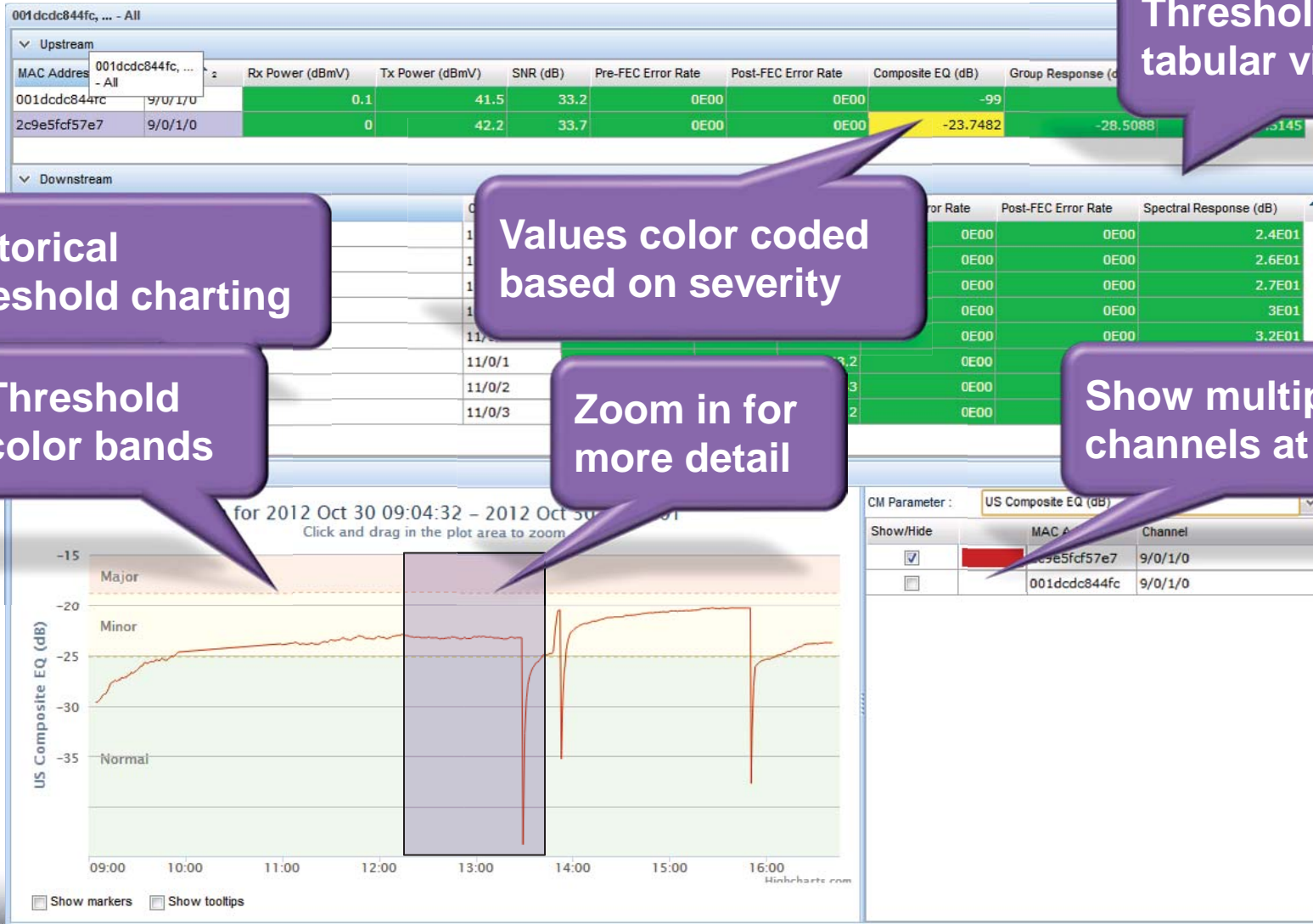
Each alarm is made of many per frequency "issues"

Issue Id	Severity	Issue Type	Frequency (MHz)	Modem Count	CMTS IP Address
47751	critical	(Downstream Noise)	0	37	
47755	critical	(Downstream Power)	0	37	
47750	major	(Upstream Power)	0	6	
47746	minor	(Upstream Power)	0	2	
47747	major	(Upstream Power)	0	2	
47748	minor	(Upstream Power)	0	2	
47752	critical	(Downstream Spectral Response)	0	2	
47753	critical	(Downstream Spectral Response)	0	2	
47754	critical	(Unreachable)	0	2	
47749	minor	(Upstream Power)	0	1	



Example Use Case

Detailed data for troubleshooting



Example Use Case

Detailed data for troubleshooting

Channel Direction: Both

Name

- lowell
 - Tap lowell_3
 - Tap lowell_27
- Service Location lowell_34
 - 3c754a345652
 - 9/0/0/0 (22.80 MHz)
 - 9/0/1/0 (34.00 MHz)
 - 11/0/0 (555.00 MHz)
 - 11/0/1 (561.00 MHz)
 - 11/0/2 (567.00 MHz)
 - 11/0/3 (573.00 MHz)
 - Tap lowell_35
- Service Location lowell_36
 - 3c754a33f9dc
 - 9/0/0/0 (22.80 MHz)
 - 9/0/1/0 (34.00 MHz)
 - 11/0/0 (555.00 MHz)
 - 11/0/1 (561.00 MHz)
 - 11/0/2 (567.00 MHz)
 - 11/0/3 (573.00 MHz)
- Service Location lowell_37
 - 2c9e5fdd60c5
 - 9/0/0/0 (22.80 MHz)

Name	SNR (dB)	Pre-FEC Error Rate	Post-FEC Error Rate	Composite EQ (dB)	Group Response (dB)	Echo Respor
9/0/0/0 (22.80 MHz)	-0.1	32.2	40.7	0E00	0E00	-30.99
9/0/1/0 (34.00 MHz)	-0.1	32.2	40.7			-37.56
11/0/0 (555.00 MHz)	3.6		39.1			
11/0/1 (561.00 MHz)	4.3		39			
11/0/2 (567.00 MHz)	3.9		39.2			
11/0/3 (573.00 MHz)	3.9		39.3			
9/0/0/0 (22.80 MHz)	-1.7	35.7	37.6	0E00	0E00	-41.95
9/0/1/0 (34.00 MHz)	-1.7	36.2	37.6	0E00	0E00	-39.28
11/0/0 (555.00 MHz)	-20.7		27.9	3.736E-02	3.5209E-03	
11/0/1 (561.00 MHz)	-18.8		29.4	8.6352E-04	3.9778E-06	
11/0/2 (567.00 MHz)	-19.4		28.5	2.6484E-02	2.8254E-03	
11/0/3 (573.00 MHz)	-22.2		26.9	1.9674E-01	6.7765E-02	
9/0/0/0 (22.80 MHz)	0	36.4	41.5	0E00	0E00	-47.69

Topology represented in tree form

Display values for US DS or both

Detailed threshold values



Buckeye Cable Case Study

Analytics system operation in a live cable system

- ▶ Initially across 11 problematic serving areas
- ▶ Later, 12th RFoG serving area also added
- ▶ Over 3000 customers

Diverse equipment from multiple manufacturers

- ▶ Two CMTS's, each from a different manufacturer
- ▶ Multiple data modem and STB types

Data integration from third party mapping and data collection systems

- ▶ Easy import of network topology and customer locations

Re-examination of existing trouble tickets w/ NTFs

- ▶ Existing tools reporting system as “OK”



Examples of Problems Detected/Resolved

1. Customer complaints of poor data speeds

- ▶ Other tools showed excellent CNR, RF levels, flatness, “no problem”
- ▶ Analytics solution detected poor FEC in return path and traced problem to group delay on highest DOCSIS channel
 - Channel moved away from filter skirt – Problem Resolved

2. Downstream FEC issue on a number of customers in one area

- ▶ Customer receive RF levels reported within acceptable range
- ▶ Analytics solution pointed to RF amplifier as suspected problem source, even though RF levels were OK
 - Suspect RF Amp module replaced – Problem resolved



Examples of Problems Detected/Resolved

3. Complaints of poor data speeds in some MDUs

- ▶ Analytics solution detected signal levels at high end of design range, pointing to leg on optical node serving MDUs
 - Leg swept, RF level lowered – Problem Resolved

4. Downstream throughput problem for one premium data customer

- ▶ Two of eight bonded channels showed poor DS FEC
- ▶ Some neighbors also complaining of problems
- ▶ Previously modem changed; drop cable visually examined but no trouble found
- ▶ iAnalytics solution pointed to drop cable as problem source
 - Drop cable carefully reexamined. Hand made, unshielded splice found behind strain relief. Proper splice made.
 - Problem Resolved



Quantifying Solution Benefits

Initial reduction in truck rolls probably not a valid measure

- ▶ Tested system will identify previously undiscovered problems requiring proactive remediation

Measures relative to truck rolls

- ▶ Measure average # of truck rolls to resolve problem
- ▶ Measure MTTR and time per truck roll

Measures relative to economic impact

- ▶ Reduction in cable modems, STBs unnecessarily replaced
- ▶ Reduction in drop cables unnecessarily replaced
- ▶ Measure customer satisfaction and customer data penetration trends – possible new marketing programs
- ▶ Determine if periodic system sweeps can be eliminated



Conclusions

Maintaining cable network performance is becoming more challenging

- ▶ Higher performance demands; more forms of interference

Existing tools provide massive amounts of data; but typically lack correlation to specific network problem

- ▶ Too much data to digest, even for RF experts

Analytics can simplify network maintenance

- ▶ Correlation of data to network and customer locations
- ▶ Conclusions as to most likely causes
- ▶ Enablement of truly Proactive Maintenance
- ▶ Performance of the tested system has been demonstrated in a demanding real network environment





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