CHEETAH TECHNOLOGIES™

CHEETAH NETWORK TRACKER™

End of Line Monitoring: 10 Applications You Never Knew You Needed

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Prologue

In the 1980's, while working in the telephone industry as a Regional Customer Service Manager, I had the ability to use systems such as ALIT, Fortel, Spartan monitoring solutions that allowed me to develop significant "robotic" analysis which provided details that prevented service disruptions from a variety of sources. Each night I could test almost 20% of all service loops, to end of line, within the State of Ohio. I could ascertain cable damage and dispatch a cable technician to repair a location before customers noticed a problem. On the trivial side, I could see a stuck coin in a pay phone across the State, and dispatch an installer to repair.

Upon entering the cable television industry, I have watched in amazement as the Industry continues to mature, and refine operational and customer service performance at an incredible rate of speed. No Industry has shown this willingness and capacity to improve and deliver excellent customer service. At the same time, there is always room for improvement. This application study represents at least 10 ways that end of line monitoring can be used.

On an unrelated note, almost any Industry that is exposed to externalities such as the environment, unpredictable weather, electronic/mechanical malfunctions and beyond, will agree that achieving the "next" level of control is always a goal. Petroleum plants deploy thousands of sensors measuring everything. Telecommunications has for years used at least five levels of status monitoring (physical, electronic, Layers 2/4) to the end of line. UG Mine safety has resulted in new legislation for mine communications and monitoring systems. As engineers and technicians, it is an over-riding goal to control information and minimize undesirable events. It is always a race to discover and repair before the customer is inconvenienced.

End of Line Monitoring – Cheetah Network Trackers

Cheetah Network Trackers are truly more than monitoring devices. That is the first key level of understanding. The application of these devices is programmable by customer service or service technicians. The information is available via Cheetah XD application system access via simple HTML web browsers. The solution is passive to the network, and has the ability to monitor the physical domain (temperature, power, physical damage), the RF domain (RF power levels) and the actual information streams (analog, DOCSIS, and digital video).

- ⇒ Trackers – designed for the CATV network, which has both an analog and digital payload.
- ⇒ Trackers (to be GA'd later this year) – designed for the CATV network, which is totally converted to digital.

Note the Trackers can be upgraded to Trackers+ via an in-service upgrade as the CATV system transitions to all-digital information streams. However, the purpose of this paper is to simply reference these Trackers as functional tools for end of line monitoring.

10 Applications of End of Line Monitoring

Application #1: FCC Proof of Performance

The first application of end of line monitoring is the mandatory FCC proof of performance. This is specifically described in FCC Title 47, part 76.601. Twice a year, a cable operator must complete a proof of performance test at a minimum of six widely distributed test points, and for every 12,500 subscribers must add an additional test point. Tests shall be defined by FCC Title 47, part 76.605.a.4. Without further description, anyone who has worked with RF electronics knows the vicious cycle of labor associated with system proofs:

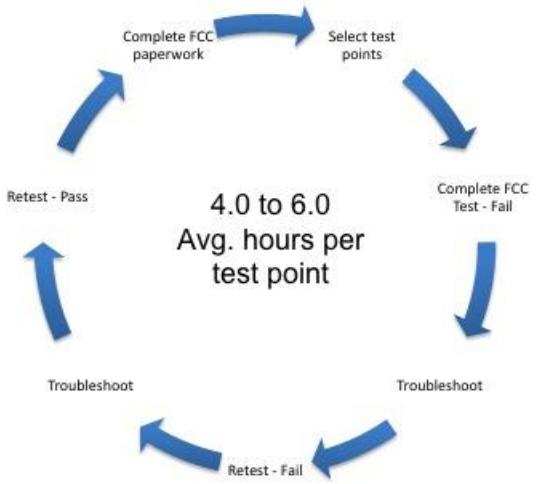

Figure 1. FCC Proof Cycle of Labor

Figure 1 illustrates the cycle of labor for each proof point, which when visited twice per year (warmest and coldest seasons are the typical test goals) the technician often experiences Murphy's Law. Everything and anything can go wrong. The initial test uncovers technical problems. Troubleshooting is required. Retest occurs and passes or fails. Additional troubleshooting is required. It becomes an on-demand cycle that takes a technician, on average 4 to 6 hours per test point, of on-demand maintenance work.

With end of line monitors at these test points, they can be tested each month as part of a preventative maintenance cycle. If a defect is discovered, "scheduled maintenance" can be programmed in off-peak time.

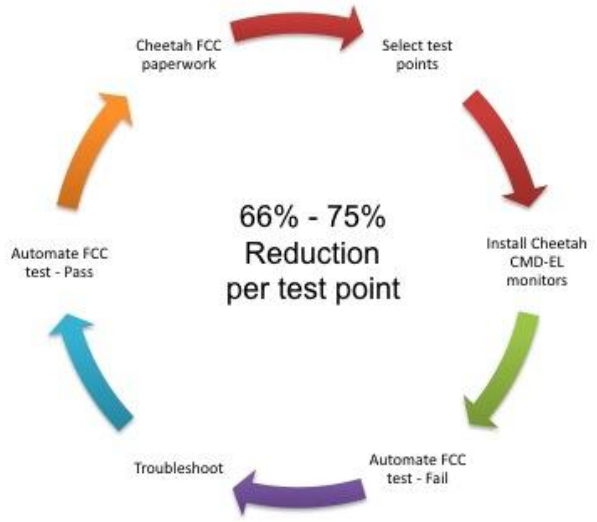

Figure 2. FCC Proof of Performance by EoL monitoring

Figure 2 reflects using a Cheetah Network Tracker to complete all testing. If a maintenance problem does exist, it can be analyzed without dispatch. Is it a physical problem? Is it an RF signal problem? Regardless, the actual labor represents perhaps one "educated" troubleshooting trip.

Immediately following the technician resolution, the Cheetah XD system will even allow the publication and printing of the necessary FCC compliance forms. 66% to 75% of the cost of loaded labor for FCC proof of performance is eliminated. (A Cheetah work study estimate).

The final comment on this application is that there is the possibility as cable television companies evolve to an all digital format that the FCC will address this with additional FCC proof of performance requirements. In this case, Cheetah end of line monitoring will be ready with support.

Expected outcome: Saving of 66% to 75% of the time associated with FCC Proofs, and an ability to schedule proof related troubleshooting as scheduled maintenance.

Application #2: Quality of Service and the Donut Effect

First, a 2007 study of CATV operators reflected a few statistics that become useful for understanding this application. 90.3% respondents stated video "service" quality is important. 71% of respondents stated video quality monitoring is important. CATV operators believe that while 50% of the quality issues are within in-home networks, there are still 30.5% of the problems that exist between the headend and the customer. Of service quality problems, 51.6% of them manifest themselves within HDTV. Finally, the most important statistic is that 61.9% of video quality problems are still reported via customer call. Only 31% are captured via network monitoring tools. (Source: MRG, 2007 Operator Video Quality Study)

With these statistics, it is equally important to acknowledge the Donut Effect. From experience, most cable systems evolved from a town center. Most headends were placed upon available property with good off-air reception and good satellite reception. Most video processing centers were placed within cable system offices. However, with suburban sprawl, most high ARPU (average revenue per user) customers have moved to the furthest boundaries of the cable system. They have moved out of cities to escape taxes, to enjoy farm land now turned into planned communities, and to essentially find affordable housing. This has created a donut effect as illustrated in figure 3.

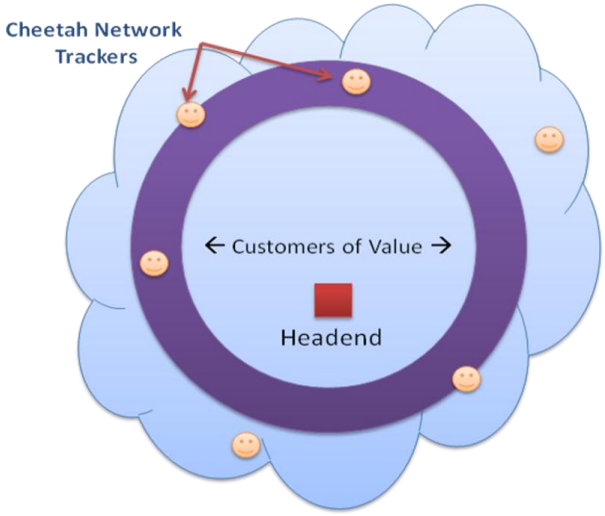

Figure 3. CATV system Demographic Donut Effect

These high ARPU customers also share some additional key characteristics. They are usually demanding customers. They are the largest users of HDTV and advanced VOD services. They are typically above average in household income. For any cable system, the benchmarks in serving these customers, based upon the statistics above, should be based upon the cable system service within their neighborhoods. Placing end of line monitoring within high value customer locations will result in additional levels of service assurance for the very best of the cable system customers.

Expected Outcome: Ability to target robotic testing to high ARPU demographic areas, whereas 31% of the video quality issues that typically impact video and advanced services occur before the home premise and after the video office.

Application 3: End of Line Microreflections Test

Figure 4. Simple network drawing of micro-reflection application

Figure 4 illustrates end of line monitoring of micro-reflections typically caused by physical plant defects. These range from loose connectors to damaged cables to moisture problems. When micro-reflections are measured by an end of line Tracker, a dispatcher can equate this measurement to footage from the test point to the office. By then cross-referencing an as-built map, the footage traced back to the office can pinpoint a location of suspicious physical damage. If there were an end of line Tracker on each cable leg, this would be a perfect application.

However, by examining two network characteristics, a few Trackers can have a significant impact. Network characteristic #1 is a historical analysis of technician dispatches by location. From experience, 20% of the network often causes 80% of the defects. Focus Trackers in areas where physical trouble has been an issue. Network characteristic #2 is an as-built map analysis to determine the end of line point that represents the longest leg of a given FSA. It will statistically have the highest probability of capturing micro-reflections between the office and EoL.

Expected outcome: Have an early detection mechanism for physical defects that may occur between the end of line robot and the video office.

Application 4: Before and After Comparisons

The world is full of before and after comparisons. Weight loss. Surface erosion. HVAC Chiller BTU's. In a cable system, the before is when the system is built, rebuilt, retrofitted, converted to digital transmission, HDTV service added, or a variety of other befores. By placing an end of line monitoring device at a reference fiber optic node and a subsequent end of line, a reference test can be completed in two manners:

- ⇒ Reference measurements for the system over time.
- ⇒ Reference measurements for the system over distance.

This is important for a number of management issues. Over time, the reference measurements will be a great indication of wear and tear on the system. The overall system health can be benchmarked in a very automated way. Over distance, the reference measurements will provide a great indication of how the technical workforce, the network itself and the environment have impacted the system over distance. What becomes even more interesting is management's ability to use the system reference over 20 or 100 systems owned by the operator. Which systems are performing better or worse? Which systems are aging more or less rapidly? Which systems are being maintained to an optimum level? Reference architectures are an essential tool of managing a cable system.

Expected Outcome: To create a "living heartbeat" of each system's outside plant to enable a wide range of management decision making, system by system.

Application 5: Intermittent Service Problem Resolution

Figure 5. Simple application illustration

One of the most significant problems in any customer service trouble report is the volume of "no trouble found" resolutions. They are caused by many things, but a small percentage represent intermittent problems that can only be resolved by a 24 hour monitoring cycle. End of line Trackers can be used in a temporary application. They can be installed at the directional tap location, at the demarcation point, and even at the set top box (Cheetah's Tracker has only been configured this way on a prototype basis, it is something to consider). With the installation of three devices that would take less than 30 minutes, a 24 hour monitoring of the situation can be used to discover hard to diagnose problems. The end result is as follows:

- ⇒ Technical resources spend minimal amounts of time on a hard to find problem.
- ⇒ Customer discontent is relieved by the proactive nature of service diagnosis.
- ⇒ Problem can be pin-pointed from a Cheetah XD user terminal, on a real time basis.
- ⇒ Alarms can be developed for the end of line Trackers should the problem be observed in real time.

This temporary installation is admittedly not the best use of an end of line robot. On the contrary, in the one or two cases that occur monthly; there are constant complaints, customer visits and often service disconnection. Three Trackers dedicated to this function would be significant tools for the cable system. NOTE: Even a temporary installation of a Tracker is conveniently done through a power passing passive device, an RG-6 cable and an F-Fitting on the device. It can be pedestal mounted or strand mounted. Since the Cheetah Network Tracker communicates through the CMTS, and has a MAC address; following prescribed Cheetah setup procedures represents an ability to use the Tracker in this manner.

Expected Outcome: A major MSO has used this Tracker configuration in a live system where they could not diagnose a customer problem. The Trackers discovered and identified the problem in a very short manner of time.

Application 6: Analysis of Externalities

Temperature, humidity, sun, shade, wind chill, type of cable and a wide range of issues impact system performance across bandwidth and with respect to attenuation, noise, distortions and power levels. When a system is designed it is designed with many imperfections that ultimately become the legacy of the system:

- ⇒ The aggregation of system design parameters may add up to over or under engineering the network, from a network performance perspective.
- ⇒ The network equipment specifications versus actual performance may have an additive aggregate impact on the system.
- ⇒ A system designed for 70° F, may actually be constructed in the dead of winter or in the heat of the summer months. Humidity, barometric pressure and a variety of other issues may come into play. It doesn't perform as designed.
- ⇒ Construction and installation activities may simply be in error, and within the QA and initial system sweep, the problem is inappropriately resolved.

It does not matter what the problems are, the best corrections are to complete subtle changes over time until the system is optimized and performing to specification. By analysis of the end of line, versus activity commissioned to improve the system, the end of line Trackers can provide real time feedback to the impact of changes. Changes made in the heat of summer can be tracked into the dead of winter. Changes made in one leg of plant can be developed into rules based action plans for an entire fiber serving area.

NOTE: Cheetah can facilitate this process via two services. Our CheetahCheck service allows us to remotely query the system and provide feedback to our customers on programs and adjustments that can be made to improve performance. Our RentACat service allows our customer to engage professional systems technicians to work with on-site personnel in training, analysis and design of proactive solutions for network performance issues.

Expected Outcome: Over the long run, each system's unique externalities will be discovered, and the optimal design of active electronics can be fine tuned.

Application 7: Technician in a Box

"Technician in a Box" is a service that truly is an essential ingredient of the end of line Trackers. These Trackers can act as a second technician in a two-person troubleshooting or system sweep process. A technician is looking to repair or optimize network performance within the Fiber Serving Area, "upstream" from the Tracker. That technician can work with a dispatcher or office technician to direct the Tracker to complete physical, RF, analog, DOCSIS, or digital test on a spectrum, carrier or channel basis. In doing so, it allows the technician to complete work, perhaps on a series of RF amplifiers while getting real time feedback.

Consider a scenario where a technician is performing a system sweep. An amplifier is set up, but running hot. The highest values of pad are already installed. The decision at this point is to return to the previous amplifier and drop RF levels. Then return to the successive amplifier and

retest and balance. With an End of Line Tracker an office technician, or even a wireless laptop could provide the sweep technician real time information about the status at a preceding or succeeding service point.

Furthermore, with Cheetah transponders within the power supplies, fiber nodes, amplifiers and other key network assets, an incredible amount of information can be available to the technical work force from a common HTML browser. In truth, the "Technician in a Box" concept is an idea in its infancy.

Expected outcome: It is estimated that roughly 33% of two person maintenance and troubleshooting can be handled by one technician.

Application 8: Cheetah Professional Services

Cheetah professional services are the most important aspect of any system operator's technical programs. Too often, because our hardware components are within power supplies, amplifiers, video offices or fiber nodes; Cheetah is presumed to be an equipment vendor. As Figure 6 reflects, we have a world class professional services organization that spends its life using Cheetah XD, a carrier class systems management application to monitor, alarm, optimize and support your workforce in delivery of the highest quality services to your end customers.

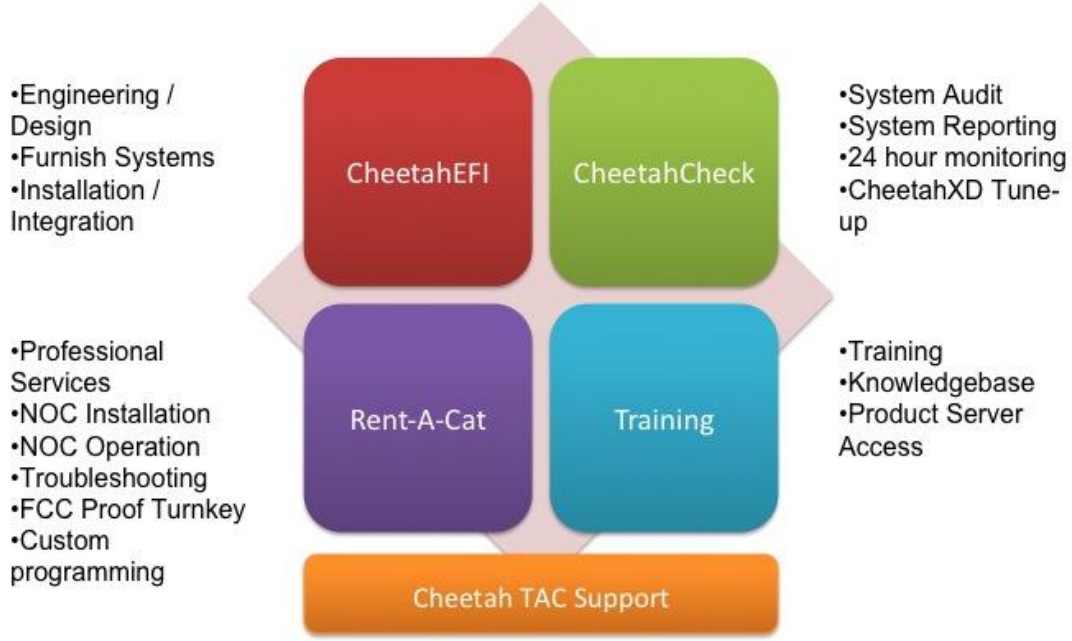

Figure 6. Cheetah Professional Services … part of your team

With end of line Trackers in place, Cheetah has the ability to remotely assist in the management of your network performance. Each service is truly designed as a cost effective alternative to achieve one of the following cable system goals:

- ⇒ Increased Network performance and reliability
- ⇒ Analog and digital service capacity planning
- ⇒ Monitoring, alarming and management of network events or outages
- ⇒ Workforce assist or productivity increases

- ⇒ Technology support of broadband networks comprised of many dissimilar and different vendor equipment
- ⇒ Cost control and reduction in expenses
- ⇒ Much, much more …

When Cheetah has end of line Trackers in place, we can work with customers to optimize their placement, to analyze the results, and to integrate the functionality into an on-going maintenance program. Most importantly, when and if the customer does not optimize the functionality, Cheetah Professional Services can set in with one of our programs.

Expected outcome: Cheetah Professional Services can incorporate Tracker measurements, optimization and broadband network recommendations into the bi-annual (recommended) CheetahCheck process, at the very least.

Application 9: Power over Ethernet Muni-WAN Network

Within each Cheetah Network Tracker, there is a 10/100 Mbs DOCSIS POE (power over Ethernet) port. These take advantage of the communications that the Tracker at its CheetahLinx Control Unit has, inherently. However, these ports can be used for development of a Municipal WAN network that can be used for a wide range of services.

Figure 7. Examples of POE terminal devices

Figure 7 points to a wide range of municipal applications that could be handled over the same network as the Trackers use to communicate. Cable systems could offer a closed circuit camera system, a wide range of voice communication services, call or fire boxes and even public address services. Understandably, these are not part of the cable television core business. However, the idea is that a single device designed to monitor the health and integrity of the network could provide communications and power to a secondary "utilitarian" network. This network could even be used as a technician talk or phone network, if enough end of line Trackers were in place.

Expected outcome: The cable system operator can extend the goodwill of a muni-WAN network to any school, college or municipality; while at the same time having a dual use Network Tracker for end of line maintenance.

Application 10: Contractor Quality Assurance

Contractors are completing a new build, rebuild, upgrade, or system maintenance within a fiber serving area. A perfect way to use end of line Trackers is to ensure they install them at end of line BEFORE the contract commences work. Take a reference measurement, and then prior to the contractor leaving each day, test the network to discover issues that could relate to service disruption. The end of line Tracker creates the possibility to discover RF signal level problems, analog or digital carrier problems, micro-reflections (mentioned above) and more.

What does this accomplish for a cable system? It allows the cable operator to pro-actively ensure that the contractor has not left a serious service affecting outage before the end of the day. In doing so, it avoids having to call-out expensive overtime technical support to fix a contractor problem, when identified by the Tracker. It allows the cable operator to measure before and after quality assurance of the contractors' work. This represents a significant cost savings over the duration of a contractor organization's employment on extensive projects.

NOTE: Even a temporary installation of a Network Tracker is conveniently done through a power passing passive device, an RG-6 cable and an F-Fitting on the robot. It can be pedestal mounted or strand mounted. Since the Tracker communicates through the CMTS, and has a MAC address; following prescribed Cheetah setup procedures represents an ability to use the robot in this manner.

Expected outcome: Reduction of after hours outages that are caused by network contractor error.