

Chaska.net and Tropos Unwire Chaska, Minnesota

A Tropos Networks Case Study
January, 2007

Photo courtesy of NASA Image eXchange.
Image use in no way implies endorsement by NASA of any of the products, services, or materials offered by Tropos Networks, Inc.

Chaska.net and Tropos Unwire Chaska, MN

Highlights

- City of Chaska, Minn. launches municipal Wi-Fi in 2004 for use by business, public services, and a growing residential population. 28% take-up after two years exceeds plan.
- Tropos products designed for fast, low-cost municipal installation and operation. Proven 802.11 wireless technology minimizes costs.
- Auto-configuring and self-healing, Tropos technology minimizes downtime and operating expenses.

While cable and DSL broadband access has been available to Chaska residents for some time, innovations in Wi-Fi and related technologies have pushed this town to the forefront in pioneering mobile broadband technology. Never before have cities – large or small – been able to deploy citywide Wi-Fi as quickly or economically as now…thanks to technology from Tropos Networks. With Tropos MetroMesh™ equipment, Chaska has been able to offer fixed and nomadic broadband service to its residents for $16.99 per month, develop a profitable business plan, and achieve greater than 28% subscriber take-rate after the service was operational for about two and a half years. Because of its Wi-Fi foundation, the Chaska MetroMesh network originally invested less than $600,000 of total capital, and was designed and installed by city workers in two months. Later, the city invested $700,000 more to accommodate additional usage and subscribers.

Tropos Networks MetroMesh architecture dramatically improves the economics of broadband access by providing up to 10 times better price/performance for municipal, residential, and small business service. MetroMesh also unlocks the potential of citywide mobile broadband for a growing range of first responder and consumer applications. Tropos MetroMesh combines patented, purpose-built, metro-scale mesh software with metro-optimized radios to provide the lowest total cost of ownership in the industry. Once deployed, users connect with off-the-shelf Wi-Fi devices, eliminating truck rolls, client subsidies, and special software. In addition, Tropos' products enable network operators, service providers, and municipalities to use a single Wi-Fi network infrastructure to simultaneously provide secure connections to multiple user communities, making the economics even more attractive.

A 13-year-old is experiencing high-speed Internet for the first time. Because of the incredibly low cost of the chaska.net service, her family was able to make the switch from their slow, phone line-hogging dial-up account. As a result, she can quickly download rich educational content, music, video clips, and more. She regularly checks the chaska.net community connection page to keep up to date on local events, and sends instant messages to her friends about their plans to attend various events within the city.

History



Chaska, Minnesota, has always been a progressive community. This suburb, located just outside the Twin Cities area, has a track record of providing attractive services to its residents. To ensure consistent levels of service and pricing, the city started its own electricity utility. With this experience, the citizens of Chaska learned they no longer had to surrender to the pricing demands and poor service of a private utility.

In 1998, the city identified a serious problem in the Chaska educational community. Existing telecommunication providers were ignoring the broadband data needs of the schools – services were too slow or too expensive, or both. To address this issue, the city formed chaska.net, a wireless Internet service provider (WISP) owned and operated by the city. At first, chaska.net implemented wireless point-to-multipoint technology to replace the traditional T-1 line required by the city's educational institutions. Shortly thereafter, chaska.net expanded its services to include businesses, which were clamoring for affordable broadband.

By the spring of 2004, more and more Chaska residents were requesting lower priced broadband and Internet connectivity that did not tie up phone lines. At the same time, city government was searching for additional ways to attract new residents and business to Chaska, and keep them in town rather than going to neighboring Minneapolis for shopping and entertainment. In response, chaska.net, with the support of the city manager, began exploring the possibility of further expanding broadband service to the city's 8,000 homes and 23,000 residents. After extensive research into the available and emerging technologies that would make this service possible, chaska.net decided on the only technology that would quickly and economically make this vision a reality – metro-scale Wi-Fi from Tropos Networks.

The city council backed the proposal, in large part because it was consistent with the council's long-standing goal of becoming a *connected community*. Chaska has long prided itself as being a tight-knit city. The council has increasingly looked to communication technology as a way to preserve the sense of community as the city grows. Additionally, the council viewed the network as an important economic development tool. As a result, the council quickly approved the project and Chaska sped down the path to becoming an *unwired* city.

Financing for the network was obtained through a loan from Chaska Electric Utility and a form of municipal debt known as equipment certificates. Under Minnesota law, municipalities can, within limits, raise debt for equipment purchases with city council

approval, provided that the term of the debt does not exceed five years. The equipment certificates are generally placed privately with institutions such as banks, rather than floated as public debt offerings. The process has been described as being as simple as doing a mortgage.

Chaska.net financed the entire $1.3-million capital investment needed for the project at an average interest rate of 4%. Chaska.net projects that it can pay the interest and principal from subscriber revenues, with plenty of room to spare.

Planning, Deployment, Optimization, and Operation

The metro-scale Wi-Fi network in Chaska was constructed using a combination of Tropos Networks' MetroMesh architecture, KarlNet point-to-multipoint (P2MP) wireless backhaul connections, an operations support system (OSS) from Pronto Networks, and an Ellacoya bandwidth management solution. The deployment also made use of the city's existing fiber network, which is owned and operated by chaska.net. The City of Chaska's electric utility owns the street lamps throughout the community, and used them for mounting the MetroMesh routers. The initial network planning and deployment phase, including site surveys, mesh router installation, network configuration, and testing, occurred in just eight weeks.



The Tropos 5110 outdoor MetroMesh router.

Tropos MetroMesh routers are built for outdoor use, with extreme temperature, high wind, and lightning strike survivability. They are specially designed for mounting on municipally owned street lamps, utilizing the many power options available on these lamp structures (usually the photo-cell sensor on the lamp's luminaire). The unit can be installed by a worker in a bucket or lift truck in under 15 minutes without any specific technology training. Tropos MetroMesh routers, once connected to power, are self-discovering and self-configuring, instantly extending the network range upon power-up. And, because of the Tropos Networks patented Predictive Wireless Routing Protocol (PWRP), more than 80% of traditional wired backhaul – the connection from the wireless access point to the city's Internet gateway – is eliminated. The result was the world's first truly wireless, metro-scale, Wi-Fi mesh broadband network.

Chaska's MetroMesh network delivers true broadband speeds (1+ megabit per second, or Mbps) to users who access the network with standard, inexpensive, and widely available 802.11 b/g adapters

and devices. No proprietary equipment or software is required for access. Additionally, mobile users have the ability to freely roam throughout the coverage area, while the Tropos MetroMesh routers seamlessly and transparently perform mesh router-to-mesh router handoffs, ensuring the client continually has an optimal, uninterrupted Internet connection. This transparent roaming is even possible throughout the city, across multiple IP subnets, as the network maintains persistent connectivity without the requirement for clients to obtain new IP addresses as they move from place to place.



By their nature, radio frequency (RF) environments are in continual flux. Tropos' PWRP continuously monitors path quality and automatically reroutes traffic around any interference, while dynamically choosing the optimal channel on which to run each section of the mesh network. Additionally, in the unlikely event of a mesh router failure or loss of wired or wireless backhaul, PWRP automatically reorganizes the mesh routers, and routes traffic by the most optimal path to the backhaul points. These adjustments happen quickly, without operator intervention. The result is a network that is always on, always available to the end user.

Because of the intelligence built into the Tropos PWRP and the rest of the Tropos MetroMesh OS, the network is easily and economically scalable. When more network capacity is needed, additional mesh routers and wired or wireless backhaul points can be added quickly and easily. Tropos MetroMesh routers automatically reorganize to take advantage of the increased capacity. MetroMesh OS and MetroMesh operation and optimization tools enable scaling the network to cover entire metropolitan areas.

In Chaska, 365 Tropos MetroMesh routers were installed to allow nearly ubiquitous (95% coverage) broadband coverage throughout the entire 14 square miles of the city. They were installed on city-owned mounting assets, predominantly streetlights with photocell-switched power. Backhaul points were deployed at 60 locations using a combination of KarlNet P2MP wireless links and connections to the city's fiber network. The installation provides the density required for service throughout the city, as well as the flexibility to increase capacity as subscriber numbers grow. By adding additional backhaul, chaska.net can increase aggregate capacity of the network without the necessity of a long and costly redesign process. The Tropos MetroMesh routers automatically reorganize to take advantage of additional backhaul.

Prior to the deployment of the Chaska network, optimization was fundamentally a trial and error process that took time to complete. Tropos's work in optimizing Chaska's network initiated the development of a new family of MetroMesh analysis and control tools which included Tropos Insight, an advanced MetroMesh analyzer and optimizer, and Tropos Drive, a drive-test appliance to determine coverage and throughput in MetroMesh networks. Both tools were used extensively in the optimization of the Chaska network.

- Tropos Insight is an advanced MetroMesh network analyzer and optimizer used to determine network-wide backhaul and mesh requirements in response to client performance. Incorporating a statistical package that includes more than 70 reports, Tropos Insight retrieves data from the MetroMesh OS instrumentation embedded in each MetroMesh router, provides system-wide data correlation, and identifies opportunities for performance optimization. This tool allows network operators to keep up with the changing demands of their user bases quickly and at low cost.
- Tropos Drive is a purpose-built, drive-test appliance that determines coverage and throughput in MetroMesh networks. It correlates coverage and throughput measurements with latitude and longitude information, enabling network operators to pinpoint coverage gaps and areas of suboptimal performance in their MetroMesh networks. The appliance can be configured to simulate the transmit power, receive sensitivity, and antenna gain of a wide variety of client devices employed in MetroMesh networks. The result is quick and easy assessment of subscriber user experience across the network.

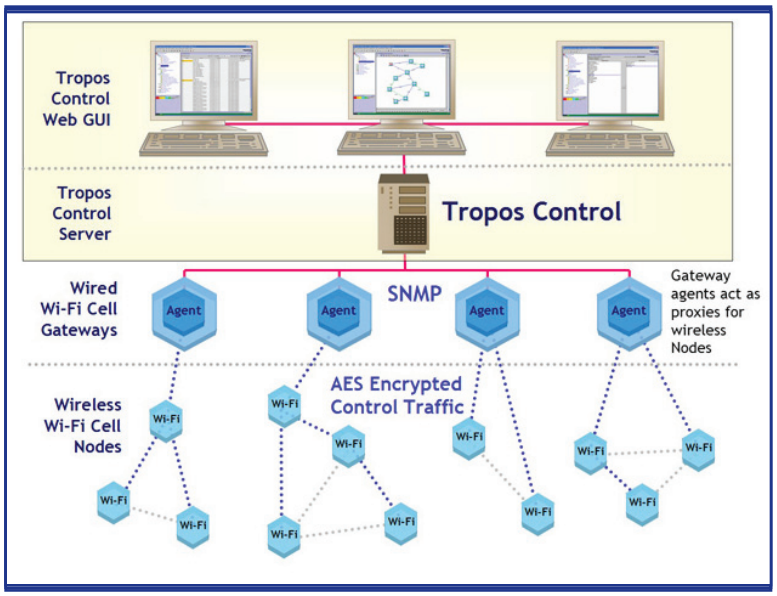
The new Wi-Fi broadband service operates in much the same way as other city-owned utilities, implemented for use by every community segment and location. It is a broadband connection the customer can use anywhere. Imagine having wireless DSL in your home, and then taking it with you anywhere you go in town. Charges for the service appear on existing utility bills, adding to the convenience for residents and cost savings for the city.

Subscriber access in Chaska is available through a very affordable service plan that provides true broadband speeds at dial-up prices – users pay just $16.99 a month, with no time-term contracts required. Additionally, subscription to the service requires no credit card information, as the broadband access charges are added as a line item to the subscriber's utility bill. The low price and convenient billing of the service allow people of all economic means to not just cross, but leap, the digital divide that exists in many communities in America today. Multiuser small business subscriptions, with up to three client devices, cost just $25.99 per month. Included in the service fee is use of a low-cost indoor Wi-Fi bridge provided by chaska.net, which extends the signal from the Tropos MetroMesh router located on a streetlight into each residence.



Network and Subscriber Management

Utilizing the Tropos Control element manager, chaska.net staff can monitor and manage the Wi-Fi network from a centralized location. Tropos Control is built on a client/server architecture. The server collects and stores management information from devices in the network, and the web-based clients provide an easy-to-use, graphical user interface to server data. Tropos MetroMesh routers configured as wired gateways communicate with Tropos Control via industry-standard SNMP, and act as management proxies for the wireless Tropos MetroMesh routers. This allows rapid and simple field deployment, minimizing costs and deployment time. Adding more users or bandwidth is straightforward – as new routers or other network devices are connected, they are automatically discovered.



The Tropos Control element manager.

Tropos Control provides multiple graphical views of the network elements, including MetroMesh router clusters and the individual routers themselves, providing at-a-glance network status and performance information. A single alarm manager interface monitors performance and identifies actual and potential problems, including backhaul or mesh router failures and path failures due to obstruction or radio frequency (RF) interference. Tropos Control also eases ongoing maintenance by enabling bulk configuration changes and over-the-air software upgrades, eliminating the need to log in to every unit during these procedures.

The Operations Support System (OSS) performs vital back office functions, tasks, and subscriber authentication. Additional security is implemented using a global MAC1 address white list, which allows only registered users to access the network. When chaska.net subscribers access the network, the OSS redirects them to a web page on the chaska.net web server. That page acts both as a login screen, where subscribers enter their username and password, and a "What's happening in Chaska" web landing page, keeping residents informed of the latest town news and events.

Unprecedented Economics and Take-Rates

Chaska.net has shown that municipal broadband can be affordable and easily deployed. By utilizing Tropos Networks metro-scale Wi-Fi technology and existing infrastructure, chaska.net is now able to provide broadband access at rates up to 60% less than competing

1 Every network device has a unique identifier known as a MAC address.

broadband services. At $16.99 per month for residential broadband access, chaska.net captured an unprecedented 20% household penetration within one month of the network being operational, was EBITDA positive in the first year, and is expected to break even on a cumulative cash flow basis in the fifth year.

Chaska is a growing community. The service is available to 8,000 homes in the city, as well as providing mobile access throughout the community. In five years, the number of households served by the network will grow to 9,000. Subscribers include residents, city employees, public safety officials, and small businesses. Tropos products offer many economic benefits to chaska.net:

- **Compelling performance**: High bandwidth for a low capital expenditure
- **Low operating expenses**: Backhaul and customer premise equipment (CPE) costs are minimized, and new subscriber truck rolls are eliminated
- **Low expansion and upgrade costs**: Automated discovery and optimization easily delivers more footprint or aggregate bandwidth
- **High reliability**: Efficient, self-healing mesh architecture and interference control provide maximum uptime
- **Flexible**: Support for fixed and mobile applications

For $16.99 per month, chaska.net provides residents unlimited, 1+ Mbps symmetrical Internet access (includes a single network connection, five e-mail accounts, 10 MB web space, spam blocker, and virus protection). With a laptop computer or other portable device, the customer can connect to the network while roaming throughout the city. For $25.99 per month, small businesses receive up to three network connections with 10 e-mail accounts and 20 MB web space. Table 1 illustrates the subscriber mix and pricing for a conservative growth rate from 20% penetration in the first year (which was achieved within the first month of operation) to a 37% take rate in five years.

Subscribers	Price	Year 1	Year2	Year 3	Year 4	Year 5
Homes Passed		7,500	8,000	8,350	8,680	8,942
Residential	$16.99	1,745	2,300	2,850	3,150	3,350
Mobile	$25.99	75	125	145	150	155
Municipal	$25.99	19	19	19	19	19
Public Safety	$25.99	12	12	12	12	12

Table 1: Service Subscriber Mix and Pricing

Operating costs are minimized by:

- **Low-cost subscriber acquisition**: Word of mouth and marketing campaign through local newspaper advertisements and residential utility bill inserts.
- **Few personnel increases**: Network operations, maintenance, and management were run

by existing personnel until subscriber growth rates exceeded expectations. Instead of adding staff, chaska.net chose to outsource its network and help desk operations.

- **No monthly network backhaul costs**: Point-to-multipoint wireless and existing chaska.net fiber infrastructure eliminated the need for dedicated infrastructure.

Chaska.net has seen phenomenal response to its low-price service. The service provider has been able to reach more than 20% market share before the end of the first month of the network going live. After two years, market penetration grew to over 28%, even as the number of households grew 6%, year over year. This success drove the need for additional bandwidth to support more applications and subscribers. Chaska.net chose to invest in upgrading MetroMesh routers, installing additional backhaul, and installing an Ellacoya bandwidth management solution in the second year. Even with the total capital investment reaching $1.3 million, chaska.net expects to break even on its investment between years five and six. If other financial benefits the City of Chaska realizes from the network (such as economic development, increased tax base, municipal employee productivity improvement) are included, break even on the investment is shortened significantly!

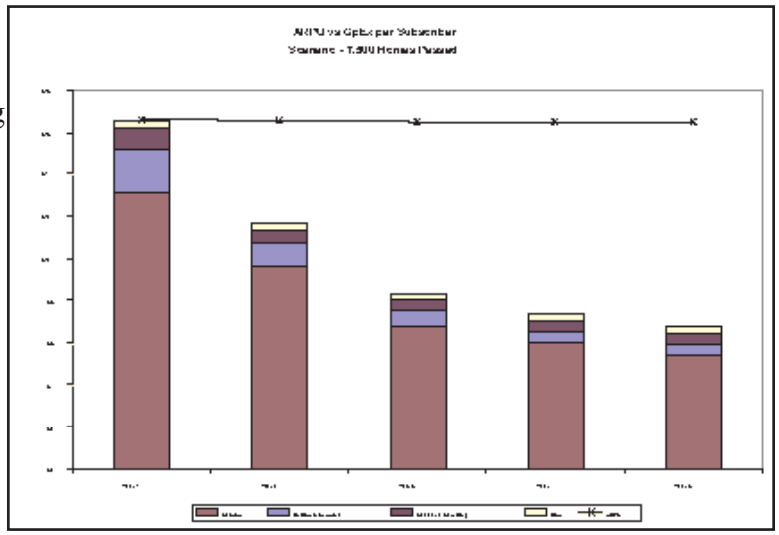


Figure 1: 5 Year Revenue vs Cost Per Subscriber

Based on the business model assumptions, Figure 1 demonstrates that the incremental cost per subscriber per month drops to less than $6.72 in the fifth year. With these types of costs and the interest seen to date, chaska.net's utilization of Tropos metro-scale Wi-Fi will continue to drive very positive financial results.

Summary 5-ear Economics	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue ($K)	$353	$464	$579	$639	$676
EBITDA ($K)	$65	$162	$280	$361	$403
Cumulative FCF ($K)	($541)	($1,088)	($808)	($447)	($44)
Cumulative CapEx ($K)	$606	$1,314	$1,314	$1,314	$1,324
CapEx / Home Passed ($K)	$80	$165	$157	$151	$147

Table 2: Summary 5-year business model results (FCF = Free Cash Flow, CapEx = Capital Expenditures, EBITDA = Earnings Before Interest, Taxes, Depreciation, and Amortization)

555 Del Rey Avenue • Sunnyvale, Ca 94085
phone 408.331.6800 • fax 408.331.6801
www.tropos.com • sales@tropos.com

©2007 Tropos Networks, Inc. All rights reserved. Tropos Networks, MetroMesh and Tropos Control are trademarks of Tropos Networks, Inc. All other brand or product names are the trademarks or registered trademarks of their respective holder(s). Information contained herein is subject to change without notice. The only warranties for Tropos products and services are set forth in the express warranty statements accompanying such products and services. Nothing herein should be construed as constituting an additional warranty. Tropos shall not be liable for technical or editorial errors or omissions contained herein.