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Ultra Low Latency Microwave Radio Systems Revolutionize HFT

Already faster than the newest latency optimized fiber networks, disruptive microwave radio technology leads the race to light speed latency

Background: Automated algorithmic trading has grown rapidly over the last 5 years to the point where it constitutes the majority of daily trading volumes. Concurrently, a number of HFT strategies have emerged in which the prospects for success are based on minimizing the time of receiving actionable data and executing associated trades, e.g., to profit from momentary price differences in a stock or other asset price as it trades in different markets. Trading firms pursuing such strategies therefore seek the lowest possible circuit latencies between their trading facilities,major exchanges, and key market data centers. So HFT firms pressure their hardware and software technology suppliers and telecom services providers to squeeze ever more latency out of their offerings. All aspects of the potential trade – basis data input delivery, algorithm decision, and trade order transmission to the applicable exchange – are perpetually optimized for fastest possible execution.

Low Latency Fiber Network Evolution: In response to latency sensitive trader demands for fast circuits, some telephone company and competitive access provider fiber network operators began to offer some low latency optimized circuit services between the New York City/New Jersey and Chicago financial centers. These circuits used the carriers' existing fiber networks and switching centers; they simply optimized traffic routes along the most direct possible path available. This provided at best an incremental improvement in latency for trading firms.

Realizing that HFT was growing and that traders would pay a premium for a faster, tiered low latency circuit offering, a new bandwidth services provider emerged that deployed a new dark fiber route along the shortest path they could achieve between NYC/NJ and Chicago. They also used the fewest possible latency adding digital regeneration sites in the network. Completed in the fall of 2010, the lowest latency tier of this service offered NYC/NJ to Chicago round trip latencies of only 13.3 milliseconds. Needing this speed to remain competitive, numerous trading firms signed long term bandwidth contracts with monthly fees that could be 8x – 10x higher than the slower regular fiber service circuits.

While these fiber optic network latency optimizations did accelerate connectivity for HFT, the inherent physical limitations of fiber data transmission put a limit on achievable speeds across these networks. Foremost, digital light pulses in a fiber optic cable travel much slower than the speed of light in a vacuum ("c"), typically only 60% - 65% of light's 186,000 miles per second speed. Additionally, zoning and topographical constraints such as mountains, lakes, rivers, cities and highways often prevent the fiber cables from being installed along the absolute shortest possible "great circle" path between two distant city endpoints.

Installing any long haul fiber is costly, but installing dedicated "shortest possible path" fiber networks over many hundreds or thousands of miles is incredibly expensive as described above. Since few if any firms have the capital to build a private low latency fiber network exclusively for their own use, they were compelled to pay high initial contract commitments and very high monthly charges to the specialized low latency fiber network service provider. Even in spending so much to get on the service providers' fastest circuits, the best an HFT firm can hope to achieve is some confidence in being just as fast as its trading competition.

The Microwave Radio Low Latency Networking Revolution: The relentless drive to achieve a lower latency advantage in trading network data transmission has continued unabated. Even before the fastest new latency optimized fiber networks were completed, a number of astute HFT firms and consultants were investigating potential technologies that could transcend the transmission media speed limit imposed by fiber optics. If fiber could only achieve data speeds of about 2/3^{rds} that of light in a vacuum, what technology and medium would support connectivity appreciably closer to that ultimate speed?

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The answer became obvious: light through the atmosphere – well, not light, but lower frequency electromagnetic radiation that also travels at very close to "c" in the Earth's atmosphere – radio waves. Specifically, highly directional microwave signals that travel just above the Earth's surface from point to point drew the interest of a number of pioneering HFT firms and industry innovators.

Microwave radio technology has been used by governments and phone companies since the middle of the last century. In the 1960s AT&T's Long Lines microwave network was the USA's original long distance telephone network. It has evolved for decades into an ever more reliable technology. The vast majority of today's worldwide mobile phone networks use digital microwave systems for network interconnection.

Terrestrial microwave radio signals travel through the atmosphere near the earth's surface at very close to the speed of light, approximately 1.5 times faster than fiber optics. This gives microwave networks a huge latency advantage over fiber networks of an equivalent distance – 5.38 vs. 8.44 microseconds per mile. And such long distance microwave networks paths can often be constructed closer to the shortest direct line path between the desired endpoints using mountaintops and existing or newly constructed radio towers as relay points. This further reduces overall network distance propagation latency.

Additionally in their favor for HFT, microwave radio networks can typically be deployed much more rapidly and at a fraction of the cost of fiber networks. This can enable smaller trading firms to be latency competitive with larger firms with greater resources. And unlike buried fiber, truly a "sunk cost", microwave radio systems can be moved and reused elsewhere should facility locations change in the future.

Thus, microwave radio for HFT has five major advantages over fiber networks: 1) faster propagation speeds = lower transmission latency 2) typically shorter end to end paths = shorter transmission distances = lower latency 3) faster to deploy 4) cheaper 5) moveable/reusable.

Microwave systems do have two disadvantages compared to fiber optic systems. First, microwave radios have significantly lower maximum bandwidth or data payload capacity due to their much lower frequency and longer wavelength. While modern long distance microwave radio systems can reliably support payloads of N x 100 Megabits per second, electromagnetic physics and regulatory limits on channel sizes precludes them from ever matching fiber optics' 100+ Gigabits per second single carrier bandwidths. However, since many of the most time sensitive trading activities require relatively small data inputs and even smaller trade execution messages, microwave radio bandwidths are often sufficient for all but the continual, truly high volume broad global market data inputs used by HFT and other algorithmic traders. In this sense the technologies are often complementary for HFT best execution: very high capacity fiber optic circuits for continual timely receipt of mass market data, and faster but lower capacity microwave radio circuits for the speediest possible trade execution.

The second disadvantage applies specifically to the number of repeater sites required for long haul intercity digital microwave radio networks. Microwave radios require line of sight from one antenna and radio terminal to the next, limiting typical maximum path distances to 30 – 50 miles depending on available frequencies, tower heights and mountaintop radio site elevations. This means that over hundreds or thousands of miles, a microwave radio network will require numerous relay sites where the signal is received, electronically processed (modem digital regeneration, forward error correction, etc.), and then retransmitted on to the next relay site. All that digital processing adds latency. Fiber optic networks require the same relay pit stops, but not as frequently over an equivalent distance since they are not line of sight limited.

Despite the higher number of regeneration points, with a 1.5 X faster propagation velocity advantage, the parties investigating the possibility of microwave radio based HFT networks determined that radios with reasonably low latencies would allow HFT microwave networks to be significantly faster than even the fastest available fiber networks. The key next step was finding digital microwave radios with sufficiently low latency.

By far the biggest global market for digital microwave radios over the last 20 years has been for mobile phone network interconnection. To address that market, almost all microwave radio systems on the market today have the extensive multiplexing, switching and routing functionality that cellular backhaul requires. All that elaborate digital processing – circuit add/drop, payload framing, buffering, robust forward error correction, etc. – adds hundreds of microseconds of latency to these radios, making them too slow for the needs of HFT networks. Conversely, any microwave radio vendor seeking to succeed in the nascent HFT application business would have to pursue software and hardware redesign or innovations that reduce the amount of latency intensive digital signal processing in their existing or new radios. Given that the HFT market for microwave systems is tiny compared to the huge global backhaul market, and only HFT needs ultra-low latency, so far it appears that the broader microwave radio industry has determined it makes no business sense to invest significantly in the innovation required to play in HFT networks. This seems especially so given the latency reductions already achieved by more nimble others.

Enter Cielo Networks: The second major microwave product introduced since the company's inception in 2006, Cielo Networks' SkyLink CG system was not designed for the cellular backhaul application. It was instead designed to be a fairly simple, bandwidth scalable, and highly reliable point to point IP digital microwave system for enterprises, wireless ISPs, and government and military applications. The SkyLink CG modem unit's compact size and efficient design resulted in a system latency that was considerably lower than other microwave modems. And that initial unimproved latency proved to be very attractive to those seeking microwave radios for HFT, as it could enable Chicago to NYC/New Jersey round trip latencies of <10 milliseconds, significantly lower than the fastest fiber circuit's 13.3 millisecond round trip latency.

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As interest in the SkyLink CG from the HFT industry quickly increased in late 2010, Cielo Networks decided to make low latency optimized microwave systems the top priority of our product development effort. As a result, SkyLink CG has become the first microwave radio specifically engineered to minimize end to end circuit latency, and the central element in a series of innovations that have progressively increased its latency advantage over the fastest fiber networks and the few competing radio systems.

So far, these SkyLink CG firmware and modular hardware innovation releases have provided the market's first microwave radio system with digital relay site latencies of < 30 microseconds (Summer 2011), < 20 microseconds (Winter 2011/2012), and < 10 microseconds (Spring 2012). Cielo Networks' resulting SkyLink CG ULL HFT network deployment successes include:

- achieved Chicago to NYC/NJ round trip latencies of < 10 milliseconds
- the first operationally effective HFT microwave network in USA and Europe
- several subsequent HFT microwave network deployments in USA
- numerous additional HFT microwave radio network deployments in USA & EU underway or impending
- maintaining a dominant market share position in HFT microwave deployments

A generic example domestic ultra-low latency microwave network is shown below.

These ultra-low latency microwave radio achievements were complemented by the Q3 2012 release of the SkyLink Mercury system – the world's first "smart" dynamically adaptive ULL microwave repeater system.

SkyLink Mercury will integrate with existing SkyLink CG ULL radios to provide relay site latencies well below 1 microsecond. Cielo has additional latency reducing innovations for the SkyLink CG in development.

To insure their continued competitiveness, HFT firms must insure their vendors have a credible product roadmap for serially reducing their system latency. Cielo has that roadmap and commitment, and has successfully achieved those technology innovations and accompanying system latency reductions time and again. Now offering the best and steadily improving end to end latency and greater cost-effectiveness, ultra-low latency microwave radio technology has become the must have solution for private HFT applications or HFT network service providers in this highly competitive industry. By far the ULL microwave market leader, Cielo Networks is faster than fiber, faster than other radios, and committed to staying that way.