Qimirluk
BY SSi MICRO

Planning Backbone Redundancy for Nunavut Communications

Prepared by D.E. Smith for SSi Micro – November 1st, 2016

PROLOGUE

This document will be of interest to both the public and private sector, for those with a policy or operational role or an interest in the planning, design, funding, deployment, operations or use of telecommunications services in Canada's remote and northern communities.

SSi Micro Ltd. (SSi) has been looking at the possible future role for fibre optic connections between southern Canada and communities in Nunavut since 2012.

SSi is a network operator headquartered in Yellowknife, Northwest Territories, and with a satellite teleport and network operations centre in Ottawa. SSi delivers communications services to consumers, business and government across the North, including all 25 communities of Nunavut. In many communities, SSi provides backbone redundancy with connectivity to two different satellites, Telesat's Anik F2 and F3.

SSi is also committed to acquire additional capacity on Telstar 19 VANTAGE (T19V) new high throughput satellite (HTS) scheduled for launch in early 2018. T19 will add significant new backbone capacity – several times more than is available today in the North- and deliver the vital benefit of greater redundancy for satellite-served communities.

SSi has been preparing for the eventual arrival of submarine fibre, supplemented where necessary by terrestrial fibre and microwave, and is designing and adapting open gateway facilities to accommodate these delivery systems.

SSi has established relationships with construction and financing partners, bid on fibre backbone projects in the North and mid-North of Canada, and commissioned expertise to assess various aspects of bringing fibre to the North.

Fibre can come to Nunavut, but its arrival will likely occur in phases. With proper planning and commitment, we will see significant growth in telecommunications capacity serving Nunavut, and the North more generally over the next two decades. Significant growth will come from the launch of new high throughput satellites, known as HTS, which will supplement the capacity that a fibre backbone ultimately brings into Northern communities.

As part of the review into fibre connectivity, SSi commissioned David E. Smith to explore and document issues related to network backup and redundancy, and the related risks of operating a northern telecommunications system with an evolving and complementary mix of satellite, fibre and microwave backbone transport technologies.

In 2002 Mr. Smith was a founder of the Nunavut Broadband Development Corporation (NBDC), a not-for-profit community champion that planned and assisted in the financing of QINIQ, Nunavut's first broadband network to deliver service in all 25 communities of the Territory. Mr. Smith held the position of NBDC President from its inception until 2009.

Beginning in 1996, Mr. Smith led the project to plan and implement information and communications technologies (ICT) for the new Government of Nunavut. On April 1, 1999, he became the first Chief Information Officer of the new Territory. Mr. Smith continued as an advisor to the Government of Nunavut, including initiation of the Nunavut Broadband Task Force.

In previous assignments, Mr. Smith was the overall project manager and first general manager of MERX, the Canadian federal government procurement system. He has also held leadership positions in significant health care, network and outsourcing organizations in Toronto, Washington, D.C., and Ottawa.

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EXECUTIVE SUMMARY

The purpose of this paper is to explore redundancy and diversity options for backbone connectivity in Nunavut. This considers a "hybrid" communications network: rather than relying on a single technology with a single source of supply, the backbone network can be comprised of satellite, fibre and microwave technologies.

Canada's North today lacks critical communications infrastructure, creating an ever-increasing digital divide between the North and southern Canada. Satellite-served communities, which comprise all of Nunavut, are at a particular disadvantage.

The connectivity deficit has a direct impact on digital democracy, inhibiting the delivery of essential government services and impeding economic and social development. The situation can be resolved through long-term planning and substantial government and private sector investments. There must be a massive increase to backbone capacity, and open gateway facilities deployed to allow for competitive and affordable service options.

To be clear, when fibre first comes to Nunavut, that will not in itself ensure all broadband and communications needs are met. Fibre will likely come in phased build-outs, and as it does, thorough planning will be required to determine the most desirable routes and the most effective strategy for backup and redundancy in the event of a fibre break.

When fibre does come to a Nunavut community, satellite capacity previously used by the now-fibre community can be reassigned to the remaining satellite communities to allow their benefit. Fibre does not compete with satellite services, but allows the growth of capacity available to all Nunavut communities.

Upon fibre launch, each new fibre community will begin to generate traffic beyond that which was previously delivered only by satellites. But unlike fibre networks further south, each new fibre community in the North is vulnerable to fibre failures or damages that can only be fixed during the ice-free season.

Network managers in these new fibre communities must be responsible for arranging backup satellite capacity for months at a time in order to ensure continued access to very basic service demands such as ATM machines, urgent health needs, public safety, airport applications and inventory control over food shipments. To depend entirely on fibre and not plan for network breaks or failures would be irresponsible. Ultimately, network managers will decide on the class of service and redundancy options they require.

Thorough planning will be required to determine the most desirable routes and the most effective strategy for backup and redundancy in the event of a fibre break.

Unlike fibre networks further south, each new fibre community in the North is vulnerable to fibre failures or damages that can only be fixed during the ice-free season.

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A. BACKGROUND

SSi delivers broadband wireless and other communications services in all 25 communities of Nunavut to consumers under the QINIQ brand, to the Government of Nunavut under a contract won based on a competitive procurement process, and to various commercial customers.

Within each Nunavut community, local or "last-mile" services are delivered from the SSi gateway to government users through local government-owned fibre. QINIQ users and other commercial customers connect to the local gateway via a broadband wireless (4G-LTE) last mile network.

All backbone services to the south are currently delivered via Telesat satellites, running through SSi gateways in each of the 25 Nunavut communities, and then on to SSi's Teleport in Kanata, Ontario, where connections are provided with the rest of the world.

For various technical reasons, security concerns, and due to contractual and cost allocation issues, consumer and government traffic on the satellites is further subdivided into groups of users, each with their own pool of capacity. This strict subdivision is inefficient since a subgroup that temporarily needs more capacity cannot use idle bandwidth in another subgroup.

The best example of this is the fact that government usage peaks every workday during business hours, while the consumer network has extra capacity. But at the end of the working day (when the government workers and schoolchildren go home), the peak usage is on the consumer network until well into the night while the government network is largely idle. Since satellite capacity is currently not shared, both the government and consumer networks suffer from exaggerated and longer peaks than need be.

Currently, SSi's gateways connect with two different satellites in nine of the largest communities in Nunavut.[2] In preparation for the launch in early 2018 of Telstar 19 VANTAGE (T19V), Telesat's new High Throughput Satellite (HTS) serving the North,[3] SSi will begin installing new Ka-Band Antennas and electronics to connect with T19. This will significantly increase the capacity available to Nunavut, and provide additional network redundancy.[4]

The T19V HTS will also bring redundant teleports (southern hubs) and geographic diversity to the network, as the plan is for T19V to be connected to a teleport outside Ottawa, in Saskatoon.[5]

All backbone services to the south are currently delivered via Telesat satellites, running through SSi gateways in each of the 25 Nunavut communities.

[1] For greater detail on how to leverage open gateway facilities in Northern communities, with separate diverse backbone connections to the south, and diverse community-based "last mile" distribution networks, see SSi's The Qimirluk Proposal: an Open Gateway Solution for Nunavut, and SSi 's April 12, 2016 presentation to TNC 2015-134, "Qimirluk: An Open Gateway to Deliver the Promise of Broadband", https://services.crtc.gc.ca/pub/ListeInterventionList/Documents.aspx?ID=224009&en=2015-134&dt=f&lang=e&S=C&PA=t&PT=nc&PST=a Click on "Presentations at Hearing". This is also posted at SSi's website, ssimicro.com.

[2] The nine communities are: Arviat, Baker Lake, Cambridge Bay, Cape Dorset, Igloolik, Iqaluit, Kugluktuk, Pond Inlet and Rankin Inlet.

[3] See Telesat's December 23, 2015 Press Release announcing Telstar 19 VANTAGE, https://www.telesat.com/sites/www.telesat.com/files/telesat/files/news/telesat_orders_t19v_from_ssl_final.pdf

[4] Sanjeev Bhatia, Senior Manager Product Marketing, "Understanding High Throughput Satellite (HTS) Technology", http://www.intelsat.com/wp-content/uploads/2013/06/HTStechnology_bhartia.pdf

[5] The World Teleport Association's company profile for Telesat, http://www.worldteleport.org/members/?id=15535517

As a Territory, until major changes to the contractual and technical status of backbone connectivity are made, Nunavut will continue to waste valuable satellite capacity. Again, this is due to a rigid allocation of capacity to subgroups of users rather than the sharing of capacity from a single pool for all users. More importantly, the rigid allocation makes it extremely difficult to provide backup and redundancy when faced with unexpected events like equipment failure.

2. Next Steps
Fibre and Microwave for Some Communities

Sooner than we might expect, land-based microwave and fibre transport facilities will bring much higher capacity to some, although perhaps only a few, communities in Nunavut.[6] Once these new connections are present, backup and redundancy to the fibre infrastructure become a significant concern, and much more flexibility in allocation of satellite capacity becomes an urgent issue. Here is why:

A. In the near term, every Nunavut community will be connected to more than one satellite, thereby providing critical backbone redundancy throughout the Territory.[7]

B. For satellite-served communities, all the satellite electronics and network components installed at the local gateway facility are standard, and new equipment can be delivered to communities by air, twelve months of the year (In Nunavut, no community has a road linking to the outside world, and there is often only one sea lift per year due to climate and community size.

C. But when undersea fibre is added to the network, a cable break may not be repaired until the location of the break is ice-free, which could take many months.

D. As a result, for communities newly served by fibre, satellite connectivity will need to continue to be present and kept alive as essential backup for the fibre.

E. Satellite capacity to back up or replace a broken fibre link may not be available in the same capacity as the fibre lost delivered, as we can expect the amount of capacity delivered by fibre to be greater than that available in the sky and, even if there were capacity available, using satellite as a replacement or backup for all the capacity on an installed fibre link could be uneconomic.

F. Nonetheless , as a source of vital redundancy and backup for fibre, satellite is ideal. Within a satellite network, it is technically possible to move satellite capacity: i) from user group to user group; ii) between communities; iii) for backup; or iii) to handle a special event on a millisecond-by-millisecond basis (contractual and security issues aside). This can be done using pre-programmed rules, or on demand.

G. Unlike satellite, for fibre networks the capacity is delivered to a specific landing point and any change to that "permanent" fixture is extremely unlikely. It either works or it is broken, but it cannot be easily shifted to cover a need somewhere else.

While most of the discussion in this paper will refer to satellite or to undersea fibre, it is likely that some fibre landings for Nunavut communities may be extremely difficult or even impossible. This is due to high tides or very shallow waters near shore, combined with ice cover for most of the year. As a result, where some communities are in relative proximity to each other, the community with the best landing site may be chosen for the fibre landing, while microwave or terrestrial fibre can then be used for transport to the neighbouring communities.

Modern microwave technology is capable of delivering multi-gigabits of capacity, but comes with the additional complication that remote sites need to be self-powered and require regular service. Dozens of similar sites already exist in Nunavut for the North Warning System and local service organizations are already familiar with servicing such sites.[8]

The community with the best landing site may be chosen for the fibre landing, while microwave or terrestrial fibre can be used for transport to the neighbouring communities.

[6] RF Wireless World, 2012, http://www.rfwireless-world.com/Terminology/Fiber-vs-Microwave.html

[7] Mark Rendell's July 7, 2015 article for edgenorth.ca, "SSi Micro Wins Big: $35 Million from Feds" https://edgenorth.ca/article/851-ssi-micro-wins-big-35-million-from-feds

[8] CBC News, April 1, 2014, "Raytheon wins 5-year North Warning System Contract", http://www.cbc.ca/news/canada/north/raytheon-wins-5-year-north-warning-system-contract-1.2594075

B. BACKUP STRATEGIES: REDUNDANCY, REPLACEMENT AND REPAIR

In theory, backup for any component of a network can be accomplished by:

- Redundancy: having more than one copy of the component immediately accessible;
- Replacement: exchanging the failed component from inventory or from another site;
- Repair: fixing the failed component in its place.

The first backup strategy, redundancy, will likely be chosen when the component cannot be quickly replaced or when no spares are available.

The second strategy, replacement, is appropriate when the replacement component is available within a reasonable time (hours, or days at the most).

Finally, if the failure does not impact services or if there is no alternative, repair in the field will be the planned strategy.

1. Satellites

The SSi network currently uses two satellites (Anik F2 and F3, and C-Band capacity in both cases), with the largest communities utilizing both satellites, providing redundancy.. Once T19V and ultimately other new HTS satellites are in service, additional redundancy (and many times more network capacity) will be available for the communities to be served with HTS.

2. Backbone Fibre

In the south, when fibre is installed on the ground it is generally accessible, and the backup strategy is usually to repair a break in place, even in winter.

But in Nunavut, and with undersea fibre, using a backup strategy of repair to a fibre backbone is more complicated. When laid under water in the Arctic, repair is only possible in ice-free conditions and only then after deploying a specialized ship and crew from the south. As a result, the backup for fibre must be a redundant path or service diversity to carry the fibre traffic while waiting (perhaps months) for the fibre repair.

The redundant path can be another fibre route to the same community from the south (a loop with two connections to the south) or, as described above, can be satellite. There will be limitations on the volume of traffic that is handled by the satellite backup strategy as described elsewhere in this paper.

3. Southern Teleports (Hubs)

As also mentioned above, when the T19V satellite is brought online in 2018, the SSi Teleport in Ottawa will benefit from geographic diversity and redundancy, with the T19V teleport to be located in Saskatoon, while SSi's Anik F2 and F3 teleport facilities are in Ottawa.

4. Qimirluk Open Gateways

SSi operates a gateway facility in each Nunavut community and these are connected to the satellites serving that community. The gateway in turn serves to connect the satellite backbone to the local "last mile" network. With the implementation of SSi's Qimirluk Proposal[9], these facilities will be converted to Open Gateways, acting as hubs connecting the backbone facilities to the local government fibre network, and accommodating co-located equipment owned by SSi and other local service providers such as other mobile service or broadband operators.[10]

The backup for fibre must be a redundant path or service diversity to carry the fibre traffic while waiting (perhaps months) for the fibre repair.

[9] See footnote 1 – the Qimirluk Proposal is posted at SSi's website, ssimicro.com.

[10] The CRTC's "Satellite Inquiry Report", http://www.crtc.gc.ca/eng/publications/reports/rp150409/rp150409.pdf

As described in more detail in SSi's Qimirluk proposal, the concept of an Open Gateway allows aggregation of all traffic from or to a community. The Open Gateway can then share a common, more economical "backbone" of satellite and/or fibre and/or microwave from and to the south, for the benefit of all customers and service providers in each community.[11]

Under Qimirluk, each Open Gateway site provides redundant satellite backbone connectivity, secure co-location space for customer and carrier equipment, towers for last mile distribution, as well as onsite support provided by local trained technicians. All of the parts can also be broken down and shipped by air any time of the year should any component of the gateway need to be replaced.

5. Summary of Backup Strategies

The SSi Nunavut Network is being built component by component to cover all Nunavut communities, and to accommodate both High Throughput Satellites and fibre for the backbone. Backup is accomplished by, where possible, providing multiple, redundant paths, and where that is not possible by planning for rapid replacement or repair.

These backup strategies include:

- Connectivity from the Northern communities to multiple satellites, and where possible, multiple fibre or microwave links to a community;
- Geographically diverse Teleports (hubs) in the south;
- Replaceable Qimirluk Open Gateway infrastructure in every community;
- Multiple "last mile" competitors and distributors, providing choice and diversity of local service suppliers.

The remainder of this paper addresses issues related to the introduction of fibre in Nunavut and the backup of the fibre links using satellite.

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[11] See the CRTC's "Satellite Inquiry Report", http://www.crtc.gc.ca/eng/publications/reports/rp150409/rp150409.pdf paragraph 147

C. RISK OF FAILURE – SATELLITE VS. FIBRE

1. Satellite Failure Issues

Satellite, microwave and fibre services have existed for decades, and the risks and probability of failure are well understood in less extreme circumstances. For land-based infrastructure, the climate and service issues in the North are thoroughly understood and the issues related to repair are well managed (although the time to repair may be longer than in the south due to the need to fly in new equipment and/or technicians).

More specifically, satellite services as experienced in the North have virtually 100% availability with only two events occurring in the last two decades where a satellite was out of service for more than a few minutes. In both cases the outage was on Anik F2 and lasted about 18 hours.[12] [13] Note that after the 2011 event, SSi provided increased redundancy using Anik F3 and as a result the 2016 event on Anik F2 did not impact some Nunavut communities and SSi services.

For satellite services, there are also short disruptions that relate to sunspots. And twice annually the sun disrupts service for a few minutes over a two-week period, an event known as "sun transits" that occurs around the spring and fall equinoxes.

Otherwise, all the risks of failure for communities using satellite services are related to issues on the ground, such as equipment damage or failure, loss of power, or software issues, and generally these problems impact a single community only.[14]

In summary, failures experienced by satellite services are rare, are usually experienced by a single community, and can typically be fixed using remote access by network operations staff, or swapping equipment on the ground.

2. Fibre Failure Issues

An alternative or supplement to satellite backbone connectivity services for Nunavut being considered is undersea fibre. The cable could start at a southern location on land, enter the saltwater in, for example, Newfoundland, Quebec, Ontario, Manitoba or the Northwest Territories, and pass by some or even many Nunavut communities. Near each Nunavut community to be served, the cable would be fitted with a "T" that leads to the community while the main cable, still in deep water, continues on its main route.

To connect a community from its nearby T, a suitable landing site needs to be selected. The cable approach to the landing site needs to be buried beneath the sea floor so that boat anchors, ice, tides, and undersea landslides do not damage the cable.

Fibre on land is usually buried along a road or railway allowance, mounted on poles or on bridges to pass over creeks or rivers, or mounted on high voltage electrical towers. These options all have different risk factors, but it is common for fibre in these locations to be damaged by human activity, floods, landslides, fires or wind. In the Northwest Territories and Yukon, for example, the separate fibre cables to Yellowknife and Whitehorse are broken several times per year. Repair time is often relatively short (hours or days) as the break location can be identified remotely and land access to the break is usually relatively easy, even in winter.

Undersea fibre in the North is another matter entirely. A break location can be identified remotely. But the repair must be accomplished by pulling and burying new cable if the break is near the shore, or by calling in a cable-laying ship from the south to fix a break in deep water.[15]

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[12] Laura Busch, October 10, 2011, paragraph 11 of Northern News Services' "Satellite Glitch causes communication headache", http://www.nnsl.com/frames/newspapers/2011-10/oct10_11sat1.html

[13] Nunatsiaq News, October 2, 2016, http://www.nunatsiaqonline.ca/stories/article/65674telesat_satellite_screw-up_knocks_out_internet_ld_phone_service_across/

[14] David A. Galvan, Brett Hemenway, William Welser IV and David Baiocchi, 2014, National Defense Research Institute, "Satellite Anomalies: Benefits of a Centralized Anomaly Database and Methods for Securely Sharing Information Among Satellite Operators." http://www.rand.org/content/dam/rand/pubs/research_reports/RR500/RR560/RAND_RR560.pdf

[15] Greg Miller, October 29, 2015, "Undersea Cables Are Surprisingly Vulnerable." http://www.wired.com/2015/10/undersea-cable-maps/

There are two different circumstances, depending where the break occurs:

A. If a break is between the offshore T and the community landing, only that community will be impacted but the communities "upstream" on the main cable will continue to be served. Of course, if the landing community also serves other communities by microwave, those related communities would also be impacted. A break near the landing site may require specialized ships that can work close to shore, special equipment on land, and supplies such as new cable delivered from the south. Likely, a break even very close to shore cannot be repaired until all ice has cleared and even then, the equipment needed to fix the break will most likely need to be shipped in by sea.

B. If a break occurs on the main deep-water cable then all communities "upstream" of the break will be impacted until a cable-laying ship arrives. Cable-laying ships cannot operate unless the water is ice-free.

One design option to minimize the impact of the second kind of break (on the main deep-water cable) is to use a fibre network loop design. For example, assume a cable is connected to Winnipeg in the south, enters tidewater at Churchill, Manitoba, runs near the west coast of Hudson Bay to serve the nearby communities, to the Hudson Strait to serve the communities on the south coast of Baffin Island and down through the Atlantic Ocean to Newfoundland to connect ***for the second time*** to the south.

The route described above would create a loop that could withstand one break of the main cable even if the break could not be repaired until the next summer; communities everywhere on the loop could be served from either end. Of course a second break would isolate communities between the two breaks. And a loop design does not protect breaks of a single fibre spur running from the network T to a community landing point.

Failures experienced by satellite services are rare, are usually experienced by a single community, and can typically be fixed using remote access by network operations staff, or swapping equipment on the ground.

3. Comparison – Satellite to Fibre Failure

As discussed above, the probability of extended failure of an entire satellite service is very low and usually a failure of satellite equipment in a single community can be repaired within a few hours or days, even in winter.

In the case of fibre, without a loop configuration, the probability of a single failure is relatively low. If it does occur however, it cannot be repaired until the water is ice-free, and in the meantime, all upstream communities would be without service.

The probability of failure of the spur to a single community is much higher than failure of the main cable (due to the risks of boat anchors, tides, ice scrubbing the bottom and landslides.) Once again, a break to the community likely could not be repaired until the next summer.

Unfortunately, experience in fixing breaks to an undersea cable in Nunavut-like conditions near land is not readily available. While Greenland has a similar climate, their geography allows Greenland communities immediate access to very deep water with minimal exposure to ice scrubbing the bottom and undersea landslides. Although they have had fibre breaks, Greenland's geographical features make it easier to create deep-water ports and to land fibre in every community.[16]

[16] Bill Schweber, May 29, 2009, "Fiber vs. Satellite for Long Links: What's Your Pick?", http://www.eetimes.com/author.asp?section_id=36&doc_id=1284130

D. WHEN SATELLITE LOAD IS SHIFTED TO FIBRE

1. Satellite Load will Shift in Phases

Fibre will likely come to Nunavut in phases, given the time, cost, and logistical and geological complications of trying to deliver fibre to all twenty-five communities simultaneously. The first phase might be a spur entering saltwater at Churchill, Manitoba and serving communities on the west side of Hudson Bay. It could be a link from the western Arctic to Cambridge Bay. Or perhaps the first phase is a spur from Northern Quebec to Iqaluit. All the above scenarios could seek to minimize the cost for a first phase, but none provides the safety and redundancy of a loop. Combining two or more phases could create a loop but would at least double the cost of the first phase; that may not be possible for budgetary reasons.

Let us assume that one of the above spurs is in fact the first phase and that the communities covered in the first phase represent 25% of the Nunavut traffic being carried on satellite. Essentially, once the fibre spur is launched, we would be able to shift upwards to 25% of that same load at fibre launch time from satellite to fibre. In such a case, several things will happen in the first few months after the fibre launch:

A. We would have upwards of 25% of the pre-fibre satellite load to spread between the communities that remain on satellite, to allow them to grow their traffic. Given current unmet demands in Nunavut for extra bandwidth, and expected continued exponential growth in the demand for data[17], the satellite communities could immediately gain access to and consume this additional capacity;

B. The communities newly connected to fibre could immediately grow their traffic usage and bridge pent-up demand by enabling new services and packages not previously available or affordable. Fibre could make available more capacity than the satellite previously allowed;

C. Let us assume the fibre communities increase their former 25% satellite capacity load share by a factor of 10 in the first year - meaning their previous consumption of 25 capacity units grows to 250 units;

D. Assume that SSi maintains the ground equipment allowing for satellite access in the new fibre communities, but without dedicating any satellite capacity to those same communities, because the satellite capacity that was freed up was instead redistributed to the remaining satellite communities;

E. Now assume that a single break occurs on the first phase fibre, which is a spur, thereby halting all traffic to the new fibre communities. And assume that the break occurs in December…

2. Outcome of a Shift to Fibre

What happens in the above scenarios when a fibre break occurs?

A. The break cannot be repaired until a cable-laying ship arrives after the ice is gone the next summer, a break of at least eight months (assuming alternative submarine fibre repair technologies are not available);

B. All satellite capacity distributed to the satellite communities must now be clawed back in order to provide some capacity to the failed fibre communities, to recreate what was previously carried on the satellite network;

C. But the failed fibre communities have already exponentially expanded their data usage due to new applications and less care on management of the capacity; their previous 25 units of capacity has grown to 250 units of demand, and the users and their software applications have become accustomed to the capacity and to lower latency;

D. But, the satellite capacity available to replace the failed fibre is only 10% of the demand in the fibre communities prior to the fibre break.

And finally, let us consider that the first two phases described above have both occurred so as much as 50% of the transport capacity is now being delivered to the communities on fibre. Hopefully the fibre route at that point is a loop so it can withstand one break without loss of service. ***But in fact, the more extensive and populous coverage of the fibre network, then the less satellite capacity there is to be "clawed back" from the smaller communities for backup in the event of a fibre break.***

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[17] See, for example, the Cisco Visual Networking Index (VNI) Complete Forecast for 2015 to 2020, which projects that global IP traffic will nearly triple at a compound annual growth rate (CAGR) of 22 percent over the next five years. https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=1771211.

Looked at from a different but equally fascinating growth perspective, Ericsson projects that by 2021, monthly smartphone data usage per active subscription in North America will be 22 GB. That is 10% more data/mo. for an individual mobile phone than the basic package per household that the Connecting Canadians Program is currently assisting in Nunavut.

E. OPTIONS FOR BACKUP OF FIBRE

There are three options:

A. Install fibre and make it clear that there is no backup in the event of a break. This is likely not a reasonable option. In fact, it could be viewed as irresponsible;

B. Claw back satellite capacity used by smaller and more remote communities to service the larger communities who are experiencing fibre failure. This will definitely upset the population not served by fibre and will only cover a small percentage of the lost fibre capacity. This is not recommended;

C. Implement changes in the technical, contractual and security procedures for the entire territory to move specific portions of the load back and forth between satellite and fibre delivery. We must recognize that perhaps only 10% of the fibre load can be duplicated on satellite as backup in the event of a fibre break.

F. RECOMMENDED SOLUTION

1. Probability of a Fibre Failure

Firstly, the most important recommendation is that the first phase of fibre deployment to Nunavut be a loop so that the backbone can withstand one break. The probability of any break is unknown due to the lack of experience with Nunavut's climate and shore conditions. But if the probability of one break in a season is 0.01 (1%) the probability of two independent breaks under the same conditions in the same season is 0.01 times 0.01 or 0.0001 or (.01%). And even then only the communities between the two breaks are at risk.

2. Percentage of Fibre Load that can be Backed Up

Secondly, all involved parties (customers, stakeholders, governments, service providers) must understand and accept that ***only a small percentage of the fibre load (say 10%) can be picked up by satellite and only then with significant changes to the existing barriers to sharing across all user groups.*** The changes to the existing barriers, described earlier in this paper, are necessary for flexibility and the proper implementation of redundancy.

3. Preparation for Fibre Outage

Specifically, the proposed solution to prepare for a fibre break causing an outage for an extended time is:

All traffic (satellite or fibre) must be classified by the network manager for each user group into the following classes, depending on its priority and the impact of losing the capability for several months if the traffic is normally carried on fibre:

Class F: Fibre traffic with no backup on satellite; a failure will cause a hard outage until the fibre is repaired even if the outage persists for months;

Class S: Satellite traffic with no access to fibre; the current status for satellite-served communities;

Class P1: Traffic normally on fibre with 100% committed backup on satellite in the event of fibre failure; ***this would be a premium service;***

Class P2: Traffic on satellite with the understanding that this satellite capacity will be diverted to fibre communities in the event of a fibre failure; ***this would be a discount service;***

Class C: Other traffic with custom features not covered in the above classes (e.g. variants of the above or for traffic that needs enhanced security handling).

All traffic must be classified by the network manager for each user group, depending on its priority and the impact of losing the capability for several months if the traffic is normally carried on fibre.

The gateway and network operator (SSi, for this paper's analysis) will market and price transport of data in the above Classes to reflect the real cost of the absence of backup, or backing up fibre with otherwise-committed satellite capacity. Specifically, prices for Class F and S will reflect the cost of delivering these services without backup. Customers will receive a credit for outages based on the time the service was not available, whether the transport is fibre or satellite.

Traffic allocated to Class P1 will travel on fibre when it is available and will be 100% covered by satellite backup in the event of fibre failure. Class P1 will pay a premium compared to Class F for guaranteed coverage by satellite. While Class P1 traffic is active on fibre, the backup satellite capacity for the Class P1 will not be used other than for testing. This same unused satellite capacity will be sold as Class P2 for a discount compared to Class S on the understanding that Class P2 capacity may not be available if needed by Class P1 traffic. The premium paid by Class P1 customers plus the discounted price paid for Class P2 will cover the cost of this satellite capacity. Regular tests of moving traffic between Class P1 and P2 must occur to ensure a smooth transition when backup is necessary.

It is expected that applications like public safety, essential government services, ATMs, airport traffic control, weather monitoring, freight logistics (especially food), cash registers and some health applications will be classified in Class P1 so they can be automatically switched to satellite when necessary.

Users of Class P2 capacity, who will be limited if the fibre fails, will be using applications like hard-drive backups, software updates and other lower priority applications such as streaming services.

4. Expected Use of Premium Fibre Service

The concept of developing classes of traffic with premium and discount prices allows SSi to offer several levels of service with network managers responsible for classifying and delivering their traffic to the appropriate class. This allows network managers to evaluate the importance of their traffic and provides a simple process for directing the traffic to the appropriate class. This avoids any analysis of packets and leaves the decisions related to classification of the traffic entirely to the users' network manager.

In some cases, SSi will also be the network manager. For example, in fibre-served communities SSi may offer basic QINIQ consumer Internet accounts with no fibre-break backup, as well as a premium QINIQ account with full backup. Another network manager using the same backbone could offer a backup (Class P1) of, say, 10% of the normal account capacity. Similarly, government network managers could choose which applications and user groups will receive Class P1 service compared to Class F. For example small text messages could always be on Class P1 as this traffic generates minimal load on the network.

At the same time, the classes of traffic concept allows SSi to properly cost the various classes, and to set prices that properly reflect the various costs. The sum of all the decisions made by all the various network managers will drive the ratios of the amount of traffic in each class. Essentially, any network manager can buy as much backup as they want while the backup capacity is not wasted when it is not used since it is sold as Class P2.

It is impractical to assume that fibre will meet all of Nunavut's broadband needs. Proper and thorough planning is required to determine a pragmatic and phased approach.

CONCLUSION

Fibre will come to Nunavut. It's only a matter of time. But it is impractical to assume that fibre will meet all of Nunavut's broadband needs and completely resolve the digital divide between the North and southern Canada.

Proper and thorough planning is required to determine a pragmatic and phased approach; one that calculates optimal sea and land routes and community access points, and, most importantly, sets forth a strategy for backup and redundancy in the event of a fibre failure. Only with such a holistic approach can Nunavut and other remote northern regions be assured of a secure telecommunications future.

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