Norcon case study

Report by

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Executive Summary

The purpose of this paper is a feasibility design and cost analysis of the voice and data network for Norcon's Ontario operations. The preliminary study is to determine the cost of voice and data traffic for Ontario operations and the cost savings that can be achieved by making upgrades to the network. In addition to the preliminary study, efforts were made to determine the minimum access rate required for each office to support the current traffic requirements. Lastly, research was undertaken to determine the estimated access rate per office to implement a VoIP solution for the Ontario interoffice voice traffic. A break down of the research is as follows:

- Current network analysis
    - The average size of each respective file transfer.
    - Total number of data calls of each duration.
    - Estimated monthly cost – (data transfer per site basis).
    - Minimum recommended access rate per office.

- Cost benefits of system upgrades
    - Comparison of V32 and V90 file transfer rate.
    - Difference in Total number of call duration from V32 to V90.
    - Monthly cost benefits switching from V32 to V90.

- VoIP – Required access rate support.

Currently the Ontario offices of Norcon (Central, Regional, and Project offices) are using V32 for the remote dial access between office locations. In the first section of the report "Current network analysis" which is an overview of the current transfer capabilities, number of calls, monthly cost and office access rates. This section will be discussed to show the current situation within Norcon's Ontario offices. In the subsequent section "Cost benefits of system upgrades", an analysis of the benefits from upgrading the current network topology from V32 toV90 will be discussed, with attention to comparing V90 file transfer rate, difference in call duration and most importantly the cost advantages of switching from V32 to V90. Lastly, in the final section "VoIP – Required access rate support" a discussion of the required access rate to support a VoIP solution using G.729 encoding for the Ontario offices will be discussed in order to determine if it is a viable option.

The current V32 implementation offers a maximum throughput of 9600 bps compared to that of V90 with a potential throughput of 33.6 kbps. With an increase of access rates, the amount of time a circuit is being held will be reduced. This reduction will lead to an increase in toll cost savings, which is approximately $4750.00 for all locations in Ontario. In addition to the reduction of toll cost, a reduction of circuit cost can be achieved with a migration from V32 to V90; currently 76 circuits are required for data transfer at a cost of approximately $3,030 a month, with V90 that cost can be reduced to approximately $2275 a month. Finally, the required access rates for VoIP implementation is discussed.

Research Caveats

The following report was commission by Nocron President, Gale Nichols. This report was commissioned to determine how much voice and data traffic are currently costing Norcon's Ontario Operations. Within Ontario there are currently 9 offices, a listing is as follows:

Central Office	Regional Office	Project Office
Newmarket	Thunder Bay	Timmins
	Sudbury	Sault St. Marie
	London	Kenora
	Kingston	Hawkesbury
	Nepean	

A map showing the geographical location of each location can be found in the appendix of the report.

In order to get a better understanding of the current traffic situation, Vince Cabalerros in Norcon's IT department was contacted. After several discussions, a topological overview of the network used to interconnect the offices in Ontario was produced. The corporate backbone consists of a connected point to point link that is used between the Newmarket and London offices at 128 kbps over Frame Relay. Beyond this, the Ontario offices exchange files on a needed basis over dialup modems, when a session is required employees simply initiate a dial up modem session through the RAS server / modem pool and make the transfer.

After discussing the network topology with Vince Cabalerros, CFO Gerry McClintock was contacted. Gerry was able to provide the monthly carrier billing to the various offices, using this information, the total (voice, data and fax) dial up minutes between the Ontario for the month of April 2004 was extracted.

	NewMk	*Kenora*	*T-Bay*	*Sudbury*	*Sault*	*Timmins*	*London*	*Kingston*	*Hawks*	*Nepean*
NewMk	0	391	6752	4709	3396	875	17698	12042	1081	8374
Kenora	2075	0	6963	1570	2470	219	2329	1505	180	728
T-Bay	8298	4889	0	2825	772	1094	3260	6021	0	1820
Sudbury	1383	2053	1688	0	1389	4921	2329	7025	360	1456
Sault	8298	489	422	1256	0	437	466	1004	0	728
Timmins	2075	196	633	4709	463	0	931	2007	0	728
London	17288	1173	2743	0	5095	1640	0	5018	720	4369
Kingston	11756	196	1266	471	1235	875	6986	0	3062	10559
Hawks	5532	0	0	0	309	0	6055	10035	0	7646
Nepean	12447	391	633	157	309	875	6520	5519	3602	0

With the use of a previous report written by Ivan McClintock, additional information was provided concerning the traffic on the dial up calls. Ivan had examined the carrier billing

as well as polling users and support people, he was able to draw the following tabulated conclusions about “call type” and “call length”.

Call type: The following table breaks down the time totals according to call type.

Source	
Percent Voice	38%
Percent Data	60%
Percent Fax	2%

Length of call: Indicates what percent of the total modem calls were committed to which call length groups.

Duration	**Percent**		**Duration**	**Percent**
1.0	10%		4.0	4%
1.5	14%		4.5	14%
2.0	1%		5.0	26%
2.5	2%		5.5	7%
3.0	18%		6.0	2%
3.5	2%			

Billing: Bell is currently billing Norcon according to the following algorithm.

a) Anything up to the first minute is a one minute charge. After one minute, charges are rounded up on a 30 second increment with 3 sec (10%) grace to the customer.

b) Norcon is paying approximately $0.06 / min for POTS within Ontario.

Ivan McClintock in his examination of Norcon’s current status was able to provide additional information for Delta Consulting; this includes Activity Interval, Session establishment and release times, as well as blocking factors.

Activity Interval: Approximately 90% of all connection time occurs during regular weekday working hours (09:00 – 17:00), the remaining traffic intervals occurs after hours and on weekends.

Session establishment and release time: The modems that are in use have a combined modem negotiation and user login time of about 22 seconds, logout takes about 8 seconds.

Blocking factor: The blocking factor is as follows:

Data blocking Factor	**Voice Blocking Factor**
Project Offices = 0.15	All offices = 0.1
Regional Offices = 0.09	

Assumptions

During the analysis phase of Norcon network infrastructure several assumptions were made by the consultants, each of these assumptions will have an effect on the overall traffic (bits/second), number of circuits required as well as the cost coming from each of the Norcon's Ontario wide offices. Within the following section we will briefly discuss these assumptions.

- Modems being used are all V.32 and have a typical compression ration of about 2:1.
- The data rate for V.32 is 9600 bps and for V.90 the data rate is 33600 bps
- That there is 22 Business days in the Month of April 2004
- The information provided by Ivan McClintock earlier report is accurate.
- The data will be evenly distributed over the working day.
- The data will be evenly distributed monthly – used to calculate annual savings for V90
- The toll charge of $0.06 / minute is for outgoing calls only and is a flat rate.
- The circuit cost for each line is 39.95 – *notice* bundling of lines can achieve a a volume discount.
- Newmarket will have the same blocking factor as the regional offices – 9%
- The recall factor will be 60% and will be constant at all sites.

Current Network Analysis

For the preliminary study, a sound overview of the current network topology is required. With this analysis it was possible to determine the interoffice data flow and voice usage, this information assisted Delta Consulting in determining the current cost for toll and circuit charges for each location in Ontario. In addition to knowing the cost for tolls and circuits, the analysis helped to determine the recommended access rate for each office location. The preliminary research also made it possible to determine the current cost for a V32 implementation. In subsequent sections of the report an analysis of the cost benefits of migrating from V32 to V90 will be made. However, the cost benefits will only show saving for tolls and circuit cost and will exclude the cost of upgrading the hardware. The following topics will be discussed in this section:

- The average size of each respective file transfer.
- Total number of data calls of each duration.
- Estimated monthly cost – (data transfer per site basis).
- Minimum recommended access rate per office.

The average size of each respective file transfer

The average size of the file transfer takes into account, when a user tries to establish a data connection. This connection requires that a session establishment and release time be factored into the calculation. When a user makes a data call, Session establishment, which is the combined modem negotiation and login time takes places (approx 22 seconds), after this establishment the user's data can be sent. After the user has completed their data transfer, session release time takes place, this release involves logout and line drop (approx 8 seconds).

To calculate the average size of a file transfer, several factors have to be taken into account, such as the session establishment time, the available time for data transfer, release time and the modem speed. To help illustrate how this calculation is made an example on how to determine the average time for data transfer can be found below:

Example:
1 minute transfer time

Session Establishment	Data Transfer Time	Release time (+ 10% Grace)
0 - 22 seconds	22 - 55 seconds	55 - 63 Seconds

The data is being transferred between 22 – 55 seconds during the session call. To calculate the average data transfer time: 55 (last second data can be sent) – 22 (when data is first being sent) = 33 seconds / 2 = 16.5 seconds (the average time). Therefore the average time that data can be sent in 1 minute is 16.5 seconds.

1.5 minute transfer time

Session Establishment	Data Transfer time (1 minute)	Data Transfer Time (0.5 minute)	Release time (+ 10% Grace)
0 - 22 seconds	22 - 63 seconds	63 - 85 seconds	85 - 93 Seconds

To find the average data call time for a 1.5 minute call requires several additional steps. First session establishment requires 0 - 22 seconds, then 22 – 63 seconds for the first minute data transfer, the half minute data transfer is between 63 – 85 seconds, then the release time is between 85 – 93 seconds. To calculate the average data time, it is the first minute data time which is 41 seconds plus the average of the half minute data time (22 seconds / 2 = 11 seconds). Therefore the average data time for 1.5 minutes is equal to 41 + 11 seconds or 52 seconds.

On the next page is a table showing the Average time for data transfer in seconds, for each of the time intervals for V32 modem at 9600 bps.

V.32(9600 bps)

Minutes	Average Time for Data Transfer(seconds)	Estimated Transfer Size (kilo bits)
1	16.5	158
1.5	52	499
2	82	787
2.5	112	1075
3	142	1363
3.5	172	1651
4	202	1939
4.5	232	2227
5	262	2515
5.5	292	2803
6	322	3091

(Average time for data transfer in seconds and the amount of data being transferred)

The above table shows the average time data is being transferred for each time interval and the estimated transfer size for that time period. Through calculations, the initial 1 minute interval had an average data transfer time of 16.5 seconds; the 1.5 minute interval had an average data transfer time of 52 seconds, and each subsequent interval grew by 30 seconds.

Total number of data calls of each duration

In this section a break down of the call duration at each office location will be discussed. By using the total connection time in minutes for each of the Ontario sites that was provided by CFO Gerry McClintock as well as information concerning the break down of interoffice call types provided by Ivan McClintock, the total number of data calls made during the time durations of 1 min, 1.5 min, 2.0 min, …..6 min will be shown. As well as the steps used to determine the results.

Total Incoming and Outgoing Minutes

Location	**Incoming(minutes)**	**Outgoing(minutes)**
NewMarket	55318	69152
Kenora	18039	9778
T-Bay	28979	21100
Sudbury	22604	15697
Sault St.Marie	13100	15438
Timmins	11742	10936
London	38046	46574
Kingston	36406	50176
Hawkesbury	29577	9005
Nepean	30453	36408
Total	**284264**	**284264**

The above table shows all the total outgoing and incoming calls in minutes made at each office locations in Ontario, this chart show total minutes for voice, data and fax. The information is the addition off all incoming and outgoing call minutes that were billed to Nocron by Bell.

With the use of a report that was done by Ivan McClintock, the total office minutes can be broken down into the following: Voice 38%, Data 60% and Fax 2% of the total minutes used.

	Incoming	**Outgoing**	**Incoming**	**Outgoing**	**Incoming**	**Outgoing**
Location	**Voice(%38)**	**Voice(%38)**	**Data(%60)**	**Data(%60)**	**Fax(%2)**	**Fax(%2)**
NewMarket	21021	26278	33191	41491	1106	1383
Kenora	6855	3716	10823	5867	361	196
T-Bay	11012	8018	17387	12660	580	422
Sudbury	8590	5965	13562	9418	452	314
Sault St.Marie	4978	5866	7860	9263	262	309
Timmins	4462	4156	7045	6562	235	219
London	14457	17698	22828	27944	761	931
Kingston	13834	19067	21844	30106	728	1004
Hawkesbury	11239	3422	17746	5403	592	180
Nepean	11572	13835	18272	21845	609	728
Total	108020	108020	170558	170558	5685	5685

Currently we are only interested the incoming and outgoing data minutes per site.
In the chart below a summarization of the total data minutes for each office location is shown.

Location	**Incoming Data Minutes**	**Outgoing Data Minutes**
NewMarket	33191	41491
Kenora	10823	5867
T-Bay	17387	12660
Sudbury	13562	9418
Sault St.Marie	7860	9263
Timmins	7045	6562
London	22828	27944
Kingston	21844	30106
Hawkesbury	17746	5403
Nepean	18272	21845
Total	**170558**	**170558**

To calculate the incoming and outgoing data minutes, the total number of data minutes for all each location is then multiplied by 60%. As shown in the table below.

	Incoming Total	**Incoming**	**Outgoing Total**	**Outgoing**
Location	**Minutes**	**Data minutes(%60)**	**Minutes**	**Data minutes(%60)**
NewMarket	55318	33191	69152	41491

Estimated monthly cost

In this section, the monthly cost for tolls and circuits charges using the current V32 modems for each office location will be discussed. Norcon is currently being charged by Bell at a rate of $0.06 / minute toll, as well as $39.95 per access circuit. To calculate the estimated monthly access charges for each location, several steps are required. First it was necessary to calculate the current toll charge per location.

In order to find the cost of tolls per office the number of outgoing data minutes is multiplied by the current toll rate of $0.06 / minute. A table of the monthly charges is below (monthly data minutes per site multiplied by toll rate).

Location	**Outgoing Data Minutes**	**Monthly Data transfer cost**
NewMarket	41491	$2,489.46
Kenora	5867	$352.02
T-Bay	12660	$759.60
Sudbury	9418	$565.08
Sault St.Marie	9263	$555.78
Timmins	6562	$393.72
London	27944	$1,676.64
Kingston	30106	$1,806.36
Hawkesbury	5403	$324.18
Nepean	21845	$1,310.70
Total	**170558**	**$10,233.54**

The above table is only for the toll charges (minutes of use) for data being sent from the various Ontario office. To get the total cost for each offices monthly data transfer minutes, the line access charges must also be included.

In order to determine the number of circuits required for outgoing and incoming for each location, the hourly circuit demand rate, and blocking factor must be known. Using Ivan McClintock's report, the blocking factor was determined for the central, regional and project offices.

Office	**Blocking Factor**
Central Office	9%
Regional Offices	9%
Project Offices	15%

With the blocking factor for each office site now known, the hourly circuit demand rate for the Ontario offices must now be calculated to find the number of required circuits for incoming and outgoing data transfers. The majority of data transfer time takes place during normal business hours (09:00 – 17:00) the remaining 10% of data transfers takes place during after-hours or weekends. The method used to find the hourly circuit demand is as follows.

To find the hourly demand rate for the incoming and outgoing circuits, the data transfer minutes for weekday minutes in the month is divided by the number of days in the month and then by the number of hours in a typical business day (8 hours). An example of which is below:

Outgoing data minutes (V32)

Location	Weekday data minutes	Workdays in April /2004	Typical business day	Demand minutes per hour
Newmarket	37342 minutes	22 days	8 hour day	212 min / hour

Incoming data minutes (V32)

Location	Weekday data minutes	Workdays in April /2004	Typical business day	Demand minutes per hour
Newmarket	29872 minutes	22 days	8 hour day	170 min / hour

With the circuit demand minutes per hour for incoming and outgoing data transfers known, as well as the blocking factors for the each offices. It is now possible to find the number of circuits required for incoming and outgoing data transfers.

Using the Extended Erlang B traffic model which is used by telephone system designers to estimate the number of lines required for PSTN connections and takes into account the additional traffic load caused by blocked callers immediately trying to call again if their calls are blocked. The four variables involved are *Busy Hour Traffic (demand minutes per hour), Blocking factor, Circuites and Recall factor*. With the busy hour traffic rate known (demand minutes per hour), blocking factor and recall factor the number of lines per site can be found. An example for Newmarket is found below:

Outgoing data circuits (V32)

Location	Hourly Demand divide by 60 min	Blocking Factor	Recall Factor	Number of Circuits
Newmarket	212 / 60	0.09	60%	7

Incoming data circuits (V32)

Location	Hourly Demand divide by 60 min	Blocking Factor	Recall Factor	Number of Circuits
Newmarket	170 / 60	0.09	60%	6

After determining how to calculate the number of incoming and outgoing circuits per site, the circuit cost per site now can be found. On the next page is a table showing the combined cost of the incoming and outgoing circuits and the total monthly cost for all the circuits.

Location	Incoming Data Circuits	Outgoing Data Circuits	Cost of Data Circuits
NewMarket	6	7	$519.35
Kenora	3	2	$199.75
T-Bay	4	3	$279.65
Sudbury	4	3	$279.65
Sault St.Marie	2	3	$199.75
Timmins	2	2	$159.80
London	5	5	$399.50
Kingston	5	5	$399.50
Hawkesbury	4	2	$239.70
Nepean	4	5	$359.55
Total	**39**	**37**	**$3,036.20**

The above table is the combined incoming and outgoing circuit costs for each site, with the toll charges as well as the circuit cost now known the total monthly cost can now be tabulated.

Location	Monthly toll cost	Monthly Circuit cost
NewMarket	$2,489.46	$519.35
Kenora	$352.02	$199.75
T-Bay	$759.60	$279.65
Sudbury	$565.08	$279.65
Sault St.Marie	$555.78	$199.75
Timmins	$393.72	$159.80
London	$1,676.64	$399.50
Kingston	$1,806.36	$399.50
Hawkesbury	$324.18	$239.70
Nepean	$1,310.70	$359.55
Total	**$10,233.54**	**$3,036.20**
	Total Combined Cost	**$13,269.70**

The combined monthly costs for each site's incoming and outgoing data circuits as well as the toll costs are shown in the above table.

Minimum recommended access.

The minimum recommended access rate is the bandwidth requirements to support the current user data transfer. By knowing what the minimum access rate at each office location is required, this will make it easier in the future to switch from V32 modems to leased lines such as ISDN or T-circuits.

To calculate the access rate for each location, several pieces of information are required. To calculate the access rate, the duration of the data calls, number of calls per duration, and the estimated data transfer size for each calls duration must be known. The table provided by Ivan McClintock concerning the average duration for each call per site is shown below.

Duration	Percent		Duration	Percent
1.0	10%		4.0	4%
1.5	14%		4.5	14%
2.0	1%		5.0	26%
2.5	2%		5.5	7%
3.0	18%		6.0	2%
3.5	2%			

The above table indicates what percentages of the total modem calls were committed to which call length groups. To calculate the access rate per site the total of number of monthly data minutes must be broken down into the percentages of the total modem calls that were committed to which call length group. In the table below, the percentages for the total modem call were committed to which call length groups for Newmarket.

NewMarket
Data(minutes) Call Length Breakdown

Call length	Percent	Incoming Minutes	Number of Incoming Calls	Outgoing Minutes	Number of Outgoing Calls
1	10%	3319	3319	4149	4149
1.5	14%	4647	3098	5809	3872
2	1%	332	166	415	207
2.5	2%	664	266	830	332
3	18%	5974	1991	7468	2489
3.5	2%	664	190	830	237
4	4%	1328	332	1660	415
4.5	14%	4647	1033	5809	1291
5	26%	8630	1726	10788	2158
5.5	7%	2323	422	2904	528
6	2%	664	111	830	138
	Total	**33191**	**12653**	**41491**	**15817**

The number of calls column is calculated by dividing the “minutes” column by the “call Length column”, with the number of calls now known it is now possible to calculate the minimum access rate for each location.

The minimum access rate for each call length group was determined in a previous section of the report. An example of which is shown below;

V.32(9600 bps)

Duration	Average Time for Data Transfer(seconds)	Estimated Transfer Size (kilo bits)
1	16.5	158
1.5	52	499
2	82	787

To determine the total access rate for each site, this required the total number of weekday modem calls per each call length, as well as the overhead for the call durations subtracted from the minutes. The overhead is defined as the time it takes to initiate and terminate a session (30 seconds overhead per call).

Duration	Total Minutes	Total Overhead Minutes	Actual Data Minutes
1	7468	3734	3734
1.5	8907	2969	5938
2	581	145	436
2.5	1096	219	877
3	9459	1577	7883
3.5	1020	146	874
4	1992	248	1743
4.5	6842	764	6082
5	12514	1252	11262
5.5	3326	302	3024
6	941	78	862

The total minute represents all minutes in which there were data session, the overhead minutes represents the initiation and termination time, the actual data minutes is the time in which data is being transmitted.

Location: Newmarket

Duration	Data transfer weekday minutes	Estimated Transfer size (in kilobits)	Total Bits Outgoing / Incoming (in bits)
1	3361	158.4	1935731520
1.5	5344	499.2	3078169344
2	392	787.2	225857808
2.5	789	1075.2	454458470.4
3	7095	1363.2	4086452160
3.5	787	1651.2	453149732.6
4	1568	1939.2	903407904
4.5	5473	2227.2	3152673792
5	10136	2515.2	5838373210
5.5	2722	2803.2	1567627462
6	776	3091.2	447077664
		Total Bits Per Month	22142979066

With the total number of bits per month for the above example now known, it is possible to determine the access rate by breaking the information down further. This is shown below.

Total Bits Per Month	22142979066
Daily Weekday Bits(divide by 22 days)	1006499048
Hourly Weekday Bits(divide by 8 hours)	125812381.1
BPS(Divide by 3600)	34949
Kilobits Access Speed	35
2:1 Compression(Multiply by 2)	70
60% Utilization(kbps)	116

The "total bits per month" is then divided by the number of business days in the month of April 2004, and then divided by the number of hours in the business day. The result yields the number of bits that are sent during a one hour period, this number is then divided by 3600 (the number of seconds in 1 hour) to yield access rate in kilobits per second for the Newmarket location. The access rate that was determined must also factor in two more details, compression and circuit utilization. The current modems in use have a 2:1 compression ratio; the access rate then must be multiplied by two to factor out compression. With compression factored out, circuit utilization must then be looked at; it is consider industry standard that a line is considered to be fully utilized at 60%, in order to achieve the access rate for Newmarket of 70 kbps, a line with the capacity of 116 kbps will be required.

Below is a table showing the required access rates in Kilobits per second for each office location.

Total Access Rates(kbps) per location

Location	**Total Access Rate Required(kbps)**
NewMarket	116
Kenora	21
T-Bay	41
Sudbury	31
Sault St.Marie	38
Timmins	20
London	79
Kingston	83
Hawkesbury	25
Nepean	62

Cost benefits of system upgrades

With the cost associated with the current V32 network now known, we begin the analysis of the benefits from upgrading V32 modems to V90 modems. In this section of the report, efforts were undertaken to determine if upgrading to V90 will see an increase in the file transfer rate compared to V32. In addition, to increase file transfer rates, what will the difference in the total number of call durations from V32 to V90 and what cost benefits will be achieved, whether a reduction in the toll cost for data minutes or will there be a reduction in the number of lines that will be required to support V90. In this section the following will be discussed:

- Comparison of V32 and V90 file transfer rate.
- Difference in Total number of call duration from V32 to V90.
- Monthly cost benefits switching from V32 to V90.

Comparison of V32 and V90 file transfer rate

In this section, the benefits of upgrading the current black box V32 modems to V90 will be discussed. In all offices across Ontario V32 modems are current in use, the maximum throughput of a V32 modem is approx 9600 bps, in comparison newer V90 modems with the new network design offer a maximum throughput of 33.6 kbps. While looking at the differences in maximum speed indicates that greater transfer rates can be achieved. In the table below, a comparison of the maximum amount of data that can be transferred in each time period for V32 and V90 is shown.

Duration	Time for Data Transfer(sec)	Estimated Transfer for V32 @ 9600 bps	Estimated Transfer for V90 @ 33,600 bps
1	16.5	158.4	5322.24
1.5	52	499.2	16773.12
2	82	787.2	26449.92
2.5	112	1075.2	36126.72
3	142	1363.2	45803.52
3.5	172	1651.2	55480.32
4	202	1939.2	65157.12
4.5	232	2227.2	74833.92
5	262	2515.2	84510.72
5.5	292	2803.2	94187.52
6	322	3091.2	103864.32

The table indicates that V90 can transfer more data per time period then that of V32, this allows for data transfer calls to be completed faster and will help to reduce the amount of time circuits are being held for. With V90 being able to send data at a faster rate, circuits will no longer have to be held as long to complete the same amount of work.

Difference in Total number of call duration from V32 to V90

With data calls being completed in a shorter duration with the use of V90 circuits, a comparison of the difference in the total number of call durations was undertaken. In this section, the difference in call durations will be discussed, with this information it will help to illustrate possible cost savings not only in toll charges, but as well as circuit costs. In the table below shows a comparison in the duration for number of minutes and number of calls for V32 and V90 at the Newmarket office.

Total number of Incoming and Outgoing Calls for V32 and V90 for Newmarket

	V32 @ 9600 bps		V90 @ 33,600 bps	
Duration	**Minutes**	**Number of Calls**	**Minuntes**	**Number of Calls**
1	7468	7468	14438	14438
1.5	10455	6970	8177	5451
2	747	373	14764	7382
2.5	1494	597	2938	1175
3	13443	4481		
3.5	1494	427		
4	2987	747		
4.5	10455	2323		
5	19417	3883		
5.5	5228	950		
6	1494	249		
Total	**74682**	**28470**	**40316**	**28470**

The above table shows the current V32 situation as well as the proposed V90 implementation concerning the incoming and outgoing data call minutes as well as the number of calls at the Newmarket office. Currently under V32, there are a great deal of long duration data calls (3 min +), these data calls hold a circuit for a great deal of time which leads to higher toll costs. In the proposed V90 implementation, a noticeable reduction in the data call minutes can be achieved, while still making the same number of data calls. A reduction in the minutes is made possible due to V90's higher transfer rate, call durations that would normally take 6 minutes in V32 will now only take 2.5 minutes in V90.

In V32 calls that would normally take 1 min or 1.5 minutes can be completed in 1 minute using V90 transfer rates. This is because of V90 higher transfer rates, in a 1 minute duration V90 can is capable of sending 554.4 bps and this speed can support V32 calls with duration of 1 and 1.5 minutes as shown in the table below.

V32 @ 9600 bps		V90 @ 33,600 bps	
Duration	**bps**	**Duration**	**bps**
1	158.4	1	554.4
1.5	499.2		

The table below shows a comparison between V32 and V90 call durations and the transfer rate capable during that duration.

V32 @ 9600 bps		**V90 @ 33,600 bps**	
Duration	**bps**	**Duration**	**bps**
1	158.4	1	554.4
1.5	499.2		
2	787.2	1.5	1747.2
2.5	1075.2		
3	1363.2		
3.5	1651.2		
4	1939.2	2	2755.2
4.5	2227.2		
5	2515.2		
5.5	2803.2	2.5	3763.2
6	3091.2		

Monthly cost benefits switching from V32 to V90

In this section the cost benefits of upgrading from V32 to V90 will be discussed. However, we will only discuss the cost associated with toll charges as well as access circuits; the cost of upgrading the hardware will not be discussed. In the previous sections the toll charges and access rate charges for V32 were discussed, in this section the cost for tolls and circuit charges for V90 will be discussed. Finally, a comparison between V32 and V90 will be discussed.

In upgrading to V90 a noticeable reduction in the number of data transfer minutes can be achieved, this reduction will help to reduce the toll costs. The table below shows the toll cost for each office.

	V90 @ 33,600 bps	
Duration	**Minuntes**	**Toll Charge**
1	14438	$866.28
1.5	8177	$490.62
2	14764	$885.84
2.5	2938	$176.28
Total	**40316**	**$2,419.02**

The reduction of toll costs are not the only benefit achieved by upgrading to V90, a reduction in circuits is possible as well, as shown in the table below

Location	**Number of Circuits**	**Cost**
NewMarket	9	$359.55
Kenora	4	$159.80
T-Bay	6	$239.70
Sudbury	5	$199.75
Sault St.Marie	4	$159.80
Timmins	4	$159.80
London	7	$279.65
Kingston	7	$279.65
Hawkesbury	5	$199.75
Nepean	6	$239.70
Total	**57**	$2,277.15

With the cost of toll charges and circuits for incoming and outgoing offices known, a comparison between V32 and V90 is now possible. The tables on the next page show the total cost for toll charges and circuit charges for V32 and V90.

Total monthly cost all locations V32

location	Toll Charges V32	Circuit Cost V32
NewMarket	$2,489.47	$519.35
Kenora	$352.01	$199.75
T-Bay	$759.60	$279.65
Sudbury	$565.09	$279.65
Sault St.Marie	$555.77	$199.75
Timmins	$393.70	$159.80
London	$1,676.66	$399.50
Kingston	$1,806.34	$399.50
Hawkesbury	$324.18	$239.70
Nepean	$1,310.69	$359.55
Total	$10,233.50	$3,036.20
	Total V32	$13,269.70

Total monthly cost all locations V90

Location	Toll Charges V90	Circuit Cost V90
NewMarket	$1,345.80	$359.55
Kenora	$190.59	$159.80
T-Bay	$410.61	$239.70
Sudbury	$305.46	$199.75
Sault St.Marie	$300.57	$159.80
Timmins	$212.85	$159.80
London	$906.48	$279.65
Kingston	$934.65	$279.65
Hawkesbury	$175.23	$199.75
Nepean	$708.72	$239.70
Total	$5,490.96	$2,277.15
	Total V90	$7,768.11

After calculating the total cost for each site for V32 and the proposed cost by upgrading to V90 is now know. The potential savings for upgrading is shown below.

Savings from upgrading V32 to V90

	V32	V90
Monthly toll charge	$10,233.50	$3,036.20
Monthly circuit charge	$5,490.96	$2,277.15
Total charges	$13,269.70	$7,768.11
	Savings	**$5501.59**

The greatest reduction in costs will be seen in toll charges, currently V32 monthly toll charges are over $10,000 with V90, the toll charges will be reduced by almost 70%. Additional savings will be scene in a reduction of the number of circuits that are currently required at each location, the current charges of $5,490.96, will be reduced by almost 60%. The possible monthly savings for upgrading to V90 is approximately $5500, and the potential yearly savings is over $66,000.

VoIP – Required access rate support

Currently all of Norcon offices are using the Plain Old Telephone System (POTS) for the office calls in Ontario. In this section a discussion of the required access rates for VoIP will be discussed. Using the results from Ivan McClintock it was determined that G.729 would meet the requirements for VoIP. G.729 is an audio data compression algorithm for voice that compresses voice audio in chunks of 10 milliseconds, it will be used because of its low bandwidth requirement, and the standard operates at 8 kilobit / second.

In order to calculate the required access rate to support VoIP, the size of a G.729 header, payload size, and additional headers must be known. The method to calculate the requirements for G.729 are below.

Calculations

G.729 frame size is 10 bytes; there are 2 samples per packet.

20 bytes (2 samples per packet x 10 bytes) + 20 bytes IP overhead + 12 UDP overhead + 8 bytes RTP protocol = 60 bytes per packet

Speed in bits per second

60 bytes x 8 (number of bits per byte) = 480 bits x 50 (packets per second) = 24000 bps or 24 kbps.

In addition, the current monthly incoming and outgoing total voice minutes for each location is needed. A table of which is below.

Location	Incoming voice minutes	Outgoing voice minutes
NewMarket	21021	26278
Kenora	6855	3716
T-Bay	11012	8018
Sudbury	8590	5965
Sault St.Marie	4978	5866
Timmins	4462	4156
London	14457	17698
Kingston	13834	19067
Hawkesbury	11239	3422
Nepean	11572	13835
Total	108020	108020

With the bits per second for G.729 known and well as the total incoming and outgoing minutes for each office, it's now possible to calculate the necessary access rate to support a VoIP solution.

In the table below, the number of bits for the monthly voice minutes for each location is shown; this number is arrived at my multiplying the total minutes by 960 KB, then the result is multiplied by 8192 to give the results in total voice traffic bits for the month.

Total Voice Minutes

Location	Total Voice(minutes)	KiloBytes	Bits
NewMarket	47299	45,406,656	363,253,248,000
Kenora	10570	10,147,642	81,181,132,800
T-Bay	19030	18,268,819	146,150,553,600
Sudbury	14554	13,972,205	111,777,638,400
Sault St.Marie	10844	10,410,662	83,285,299,200
Timmins	8618	8,272,934	66,183,475,200
London	32156	30,869,376	246,955,008,000
Kingston	32901	31,585,114	252,680,908,800
Hawkesbury	14661	14,074,714	112,597,708,800
Nepean	25407	24,390,893	195,127,142,400
	216041	207,399,014	1,659,192,115,200

The monthly data minutes is multiplied by 960 KB, this is because during a phone call the circuit is continuously open between the two phones. Telephone conversations over the traditional POTS are transmitted at a fixed rate of about 64 kilobits per second (Kbps), for a total transmission rate of 128 Kbps. Since there are 8 kilobits (Kb) in a kilobyte (KB), this translates to a transmission of 16 KB each second the circuit is open, and 960 KB every minute it's open.

The result of multiplying the voice minutes by 983,040 bytes gives the total data minutes in bytes for the month, then multiplying the total bytes for the month by 8, gives the total voice traffic in bits per month.

In the table below, the total voice traffic in bits is shown, as well as the total VoIP traffic for the month using the G.729 codec, the total VoIP traffic is calculated by multiplying the total voice traffic in bits by speed of G.729 in bits per second (24000 bits / second). With this result the access rate for each location can be calculated.

Location	bits	Voice over IP(VoIP) bits
NewMarket	371,971,325,952	68,109,984,000.00
Kenora	83,129,479,987	15,221,462,400.00
T-Bay	149,658,166,886	27,403,228,800.00
Sudbury	114,460,301,722	20,958,307,200.00
Sault St.Marie	85,284,146,381	15,615,993,600.00
Timmins	67,771,878,605	12,409,401,600.00
London	252,881,928,192	46,304,064,000.00
Kingston	258,745,250,611	47,377,670,400.00
Hawkesbury	115,300,053,811	21,112,070,400.00
Nepean	199,810,193,818	36,586,339,200.00
Total	**1,699,012,725,965**	**311,098,521,600.00**

With the total VoIP traffic for the month calculated it is possible to determine the access rate required to support the traffic for each location. The table below shows the required access rate.

Location	Voice over IP(VoIP)	bps	kbps
NewMarket	68,109,984,000.00	107,497	107
Kenora	15,221,462,400.00	24,024	24
T-Bay	27,403,228,800.00	43,250	43
Sudbury	20,958,307,200.00	33,078	33
Sault St.Marie	15,615,993,600.00	24,646	25
Timmins	12,409,401,600.00	19,586	20
London	46,304,064,000.00	73,081	73
Kingston	47,377,670,400.00	74,775	75
Hawkesbury	21,112,070,400.00	33,321	33
Nepean	36,586,339,200.00	57,744	58
Total	**311,098,521,600.00**	**491,001**	**491**

The access rate is calculated, by first dividing the total monthly VoIP traffic by the number of days in the business month, next divide the result by the number of hours in a business day, and then finally by 3600 seconds, to find the bits per second.

Example

NewMarket 68,109,984,000.00 bits per month / 22 days = 3,095,908,364 bits per day
3,095,908,364 bits per day / 8 hours per day = 386,988,545 bits per hour
386,988,545 bits per hour / 3600 seconds per hour = 107,497 bits per second

The recommended access rate for each location is shown in the table below.

Location	Access rate (kbps)
NewMarket	108
Kenora	25
T-Bay	44
Sudbury	34
Sault St.Marie	25
Timmins	20
London	74
Kingston	75
Hawkesbury	34
Nepean	58

Conclusion

The project began with a current network analysis, current Nocron is using V32 for remote dial access between each of the Ontario office. The first area of interest was determining the average size of each respective file transfer for the call duration periods that is currently possible using V32 modems. The average size for each respective file transfer removes the overhead (session initiation and termination time) from the actual time that data can be transmitted. Once the file transfer rate was known, the next step in the project was to determine total number of data calls for each location.

The monthly carrier billing information was required and supplied by Gerry McClintock, the billing information was then broken down using a previous report supplied by Ivan McClintock into three areas of interest, Voice, Data and Fax minutes. With a break down of the data minutes for each site, the estimate monthly cost for data was calculated, with the current flat toll rate of $0.06 / minute of use, Norcon is paying $10,233.54 per month for all Ontario office locations. The toll charge is not the only cost that has to be incurred by Norcon, circuits that are used for the data transfer are costing Norcon $3,036.20 per month for all location. With the average size of each respective file transfer per call duration as well as the cost of toll and data circuits known, the next phase we find the minimum recommended access rate per office.

The minimum recommended access rate, is the current support required to send data traffic. By having the minimum access rate to support the current traffic, makes it easier for when migrating from dial up lines to lease lines to provide office connectivity.

In the “cost benefits of system upgrades” section of the report an an analysis of the benefits from upgrading the current network topology from V32 toV90 was discussed. If there were a migration from V32 to V90, a sizable increase in the file transfer rates could be achieved.

Duration	Time for Data Transfer(sec)	Estimated Transfer for V32 @ 9600 bps	Estimated Transfer for V90 @ 33,600 bps
1	16.5	158.4	5322.24

The benefits of increasing the transfer rate per site, allows for the data call durations to be reduced. The reduction in data call durations reduces the number of minutes that a circuit has to be held, this reduces the toll rates that will have to be paid for Norcon’s Ontario offices. In addition to the cost savings in the number of tolls being paid, and there is also a reduction in the number of circuits for each office.

The upgrade of the V32 network to V90 has to major cost benefits, a reduction in the number of tolls that have to be paid at each office as well as a reduction in circuits costs for each location.

	V32	V90
Monthly toll charge	$10,233.50	$3,036.20
Monthly circuit charge	$5,490.96	$2,277.15
Total charges	$13,269.70	$7,768.11
	Savings	**$5501.59**

Lastly, in the final section "VoIP – Required access rate support" is a discussion of the required access rate to support a VoIP solution using G.729 encoding. To find the access rate for VoIP, we began by finding the maximum size transported in one packet in G.729, this included the overhead for UDP, TCP and RTP. In one second G.729 transfers 24000 bps or 24 kbps.

The total data minutes are converted to seconds, after the conversion the seconds are multiplied by 24,000 (G.729), the resulting number is divided by 22 (the number of days in the business month), then by 8 (hours in business day) and finally by 3600 (number of seconds in one hour) to give the required access rate to support VoIP.