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Research paper

Importance of standardization in Wide Area Network capacity management for future cost optimization

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Abstract

For Enterprise organization, IT (Information Technology) budget is getting reduced and Organizations are focusing on optimizing Operating cost to save money which can be used in Security enhancement to protect the IT / OT (Production) asset or in innovative solution deployment to get competitive advantages in the market [1] [2]. As in the technologies are undergoing paradigm shift from closed end to open ended (cloud / IoT centric) Solution and customer needs secured connectivity for reliable service delivery, Next Gen solution approach must be standardized for easy governance for the future.

Keywords: *High Cost QOS (Quality of Service) Enabled Ethernet Based Solution; Wide Area Network; WAN Solution Standardization; WAN Bandwidth.*

1. Introduction

For large Enterprise organization, Wide Area Network cost is under budget cut situation and IT department always face real challenge how to get best fitted technical solution within limited budget. Standardization of WAN Capacity Management is essential which helps in Overall Cost Optimization [3] in the future.
The Standardization includes clear guidance which site will have what kind of WAN Links – MPLS or Internet VPN, what will be minimum Bandwidth requirement considering the desired applications to run seamlessly with the projected concurrent user number. The capacity planning will help to have right sizing of WAN links so that circuit will not be over / under utilized in general and maximization of ROI and lowering the TCO. If the WAN Bandwidth is not rightly sized, then WAN Circuit may be over utilized resulting poor application response and negative perception to the end user. If application access response if not good enough business operation will be highly impacted and performance of customer service will be degraded [4] [5].

2. Literature survey

Paul F. Kirvan (2017) formulated the techniques / methods has been described for WAN performance monitoring and Capacity management but no capacity planning related to cloud move has been highlighted. It also highlighted the open question how much WAN Bandwidth will be enough which is not yet got the right answer [6] [7].
Cisco extensive research (2005) has highlighted netflow tool is the core foundation of capacity planning by in depth analysis [8].
William Nametka (1999) highlights that for Capacity planning Bandwidth upgrade is not always the only solution, rather rationalising and optimizing WAN usage would add great value in effective usage of WAN to connect corporate network connectivity [9].
Riverbed Technology and Liveaction are the pioneer in the netflow utility tool / appliance which add real value in application analysis across the wan and contribute in capacity management by predictive analysis [10] [11].
In a White Paper on WAN Bandwidth / Application impact analysis by BSC Systems, Inc. (2007) focuses on application specific Bandwidth requirement but nothing related to cloud application move has been incorporated [12].
VessBakalov (2016) highlighted the relevance and lesser demand of capacity planning in cloud computing as cost optimization initiative. But, this is purely a debatable open question and has no concrete answer from WAN Perspective [13].
Kristina Lengyel (2015) has focus for importance of network readiness related to cloud migration [14].
Dimension Data (2017) provides readiness analysis for cloud migration as a service but WAN impact analysis steps are yet to be covered in their portfolio [15].
In a white paper on The Definitive Guide to Networking for Office 365, Zscaler (2017) focused on latency and other network parameters but not on WAN Bandwidth [16].
Barracuda (2015) conducted Osterman Research to define Best Practices for Migrating to Office 365 but in depth network readiness and associated impact during the post migration phase has not been defined clearly which opens further research opportunity [17].

3. Methodologies

Performance of the Customer Service is important as customer service operation plays pivotal role in better customer's experience and customer's retention. The Management KPIs for Standard WAN Capacity Planning are as below:

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3.1. Site categorization (based on user number)

It is important to classify the sites based on number of users. Classification of sites will help to draw line of criticality of that site based on which the Connection technology and WAN Bandwidth will be rightly sized.

Table 1: Categorization of Site Based on Number of Users

Number of Users at Site	Site Categorization
0 – 20	XS – Very Small Site
21 – 50	S – Small Site
51 – 100	M – Medium Site
101 – 150	L – Large Site
151 – 250	XL – Extra Large Site
251 – 500	XXL – Double Extra Large Site
500+	XXXL – Triple Extra Large Site

3.2. Site categorization (based on business criticality)

The main KPIs of deciding factors of various sites are either location – Head Office in the Country where top management Team operates business, Data Center where Servers are located or Sales office etc or production environment which generates more revenue in terms of business transaction. Details are as follows:

Table 2: Categorization of Site Based on Business Criticality

Site Categorization	Description
Gold Site	Very Critical Sites – Like Head Office, Data Center, Production Control Office etc.
Platinum Site	Critical Sites – Like Regional Head Office, Large Production Site etc.
Silver Site	Important Sites – Large Branch Site, Medium Production Site etc.
Bronze Site	Branch Site, Small Production Site.
Copper Site	Sales Office / Distribution Office
Iron Site	Small Sales Office

3.3. WAN solution categorization

It is important to standardize WAN Solution, available from different WAN Service Provider. It is always better to have single provider to manage Global Wide Area Network by providing connectivity to the Head Office and Branch Offices for getting better service governance of single platform and getting Commercial benefit. But it may be challenging that single provider may not have presence to all the locations and price may not be competitive. Multi Provider strategy is one of the crucial decisions that enterprise must take. Based on strong presence in the region, Enterprise should consider maximum 5 WAN Service Provider to provide connectivity to the sites.

Table 3: Categorization of Site Based on Business Criticality

WAN Solution Type	Description
Type A	Dual MPLS with Full Path Diversity with Dual POP
Type B	Dual MPLS with Non-Full Path Diversity with Dual POP
Type C	Dual MPLS with Non-Full Path Diversity with Single POP
Type D	Single MPLS
Type E	Primary MPLS Internet Based VPN as Backup
Type F	Dual Internet Based VPN Primary / Backup
Type G	Single Internet Based VPN
Type H	Type A + SDN (Software Defined Network) + NFV (Network Function Virtualization)
Type I	Type B + SDN (Software Defined Network) + NFV (Network Function Virtualization)
Type J	Type C + SDN (Software Defined Network) + NFV (Network Function Virtualization)
Type K	Type D + SDN (Software Defined Network) + NFV (Network Function Virtualization)
Type L	Type E + SDN (Software Defined Network) + NFV (Network Function Virtualization)
Type M	Type F + SDN (Software Defined Network) + NFV (Network Function Virtualization)
Type N	Type G + SDN (Software Defined Network) + NFV (Network Function Virtualization)

3.3.1. Sample WAN architecture

In a typical Enterprise Network environment, which operates globally, usually have multiple WAN service providers. Strongest WAN Service providers are selected in each region and that creates complex situation for vendor management and routing management. Blame game start and route re distribution requires complex BGP setup and skill set upliftment of technical resources. Below is the technical high level diagram of global WAN where two data Center has been shown in redundant mode with Internet break out point firewall proxy etc. and Under the WAN provider (Single Provider) different sets of connectivity, MPLS, MPLS + VPN, Exclusive VPN etc. has been demonstrated.

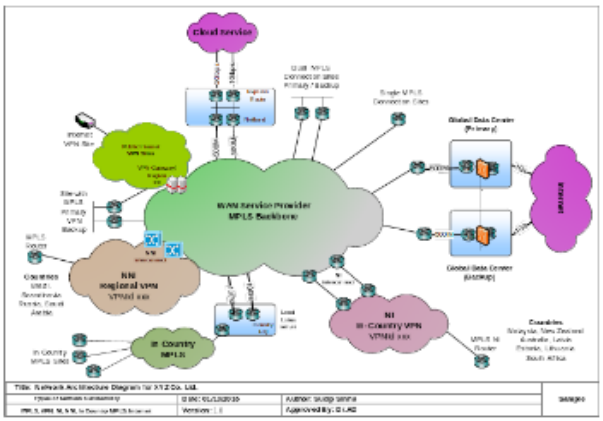


Fig. 1: Sample WAN Architecture.

3.4. Quality of service standardization

It is essential to standardize Quality of Service for the MPLS WAN Links so that application performance can be guaranteed. QOS will ensure minimum allocated bandwidth will be reserved to provide certain assurance of seamless application access when circuit will be over utilized. QOS is effectively only available on MPLS. Since internet is uncontrolled and application cannot be guaranteed over public internet, effective QOS will not be achieved over Internet based VPN Services.

Application Name	Per user WAN BW requirement (Kbps)	User # at site	% of concurrency of user #	Concurrent User#	WAN BW requirement (Kbps)
ERP Software	32	10	50%	5	160
Middleware	32	10	30%	3	96
Intranet	20	10	40%	4	80
Internet	48	10	60%	6	288
Handheld Apps.	40	5	100%	5	200
VoIP	64	10	20%	2	128
Email Client	20	10	80%	8	160
Chat Client	5	10	50%	5	25
					1137
Headroom 25% extra					340
Total WAN					2 Mbps

BW Proposed		

Sample QOS Profiling can be followed by Enterprise Organization across Global WAN Services.

Table 4: COS Profile with WAN.

COS Profile	Description	% of WAN BW
COS1	EF for UC Voice / VOIP	5% can be increased on demand (Generally Strict Priority). DSCP EF Category.
COS2V	Video Conferencing	25% of the remaining BW. DSCP AF41 Category.
COS2	Critical Applications	25% of the remaining BW. DSCP AF3x Category.
COS3a	Important Applications	15% of the remaining BW. DSCP AF2x Category.
COS3b	General Business Applications	10% of the remaining BW. DSCP AF22 Category.
COS4	Best Effort Traffic	25% of the remaining BW. DSCP Best Effort (BE).

The COS1 is for Unified Communication VOIP requirement. Considering 32Kbps or 64Kbps per voice call BW requirement [Compressed or Uncompressed], focusing needs to be given on assumption of number of concurrent VOIP calls [Inbound + Outbound] to calculate minimum COS1 bandwidth requirement for the WAN Link.

Similarly, COS2V is for Video Conferencing. It is essentially for Device based Video Conferencing System to secure 1Mbps per device for Video Conferencing. Laptop based VC using Video Conferencing client should not QOS functional as optimum way.

In Summary Concurrency factor is important to rightly size COS1 and COS2V bandwidth for WAN QOS.

WAN Acceleration and Compression technology plays a vital role for compression of WAN traffic so that with low bandwidth link high amount of traffic can be traversed. Only point of concern is WAN Compression appliance requires to be installed in locations where Customer wants to get benefit of WAN compression acceleration. If WAN compression device can compress 50% of the WAN traffic, then effective utilisation of 2Mbps WAN link will be around 1Mbps so more headroom will be available to send more traffic across the same WAN Link. The site where no WAN compression device is installed – the WAN traffic will be sent being uncompressed. To have WAN compression device in every location may be costly approach but Enterprise customer should consider this technology as standard best practice framework to save cost of Bandwidth upgrade. Following are high level cost structure for WAN compression device deployment –

Pricing Example WAN Compression Device

WAN Bandwidth (Mbps)	Monthly Cost for WAN Compression Device (USD)
<=10	600
>10 - <=20	750
>20 - <=50	1500
>50 <=80	3500
>80 <=200	4000
>200	4500

3.5. WAN bandwidth calculator

Enterprise Organization should essentially develop organization specific WAN Bandwidth calculator which will be very helpful in Capacity planning for new site, new application deployment for existing site or on premises to cloud application move. This WAN Bandwidth calculator will be helpful in right sizing the WAN Link BW for seamless application access. The WAN BW Calculator will also be used for readiness analysis for any upcoming project to make sure existing BW is capable enough or require WAN Bandwidth upgrade.

The key components involved to develop WAN Bandwidth Calculator are as below –

- Identify the Applications
- Gather per user BW requirement for those applications
- Gather Number of users at sites
- Anticipate number of user % of the site for each application

Also, it must be considered that in MPLS QOS Tail end packet drop will be observed if the WAN Utilization goes beyond 75%. 25% headroom should be always maintained to avoid packet drops which can result poor application performance.

Examples of WAN BW Calculators are as follows in Table 5

Table 5: Sample WAN Bandwidth Calculator for New Sites.

Note: For USA T1 [1.54Mbps] is available, but for rest of the Globe 2Mbps is the minimum standard so 2Mbps is recommended to support the above requirement.

Sample WAN BW Calculator for WAN Readiness Analysis for Cloud based Email and Collaboration Software Deployment –

Baseline Information –

Name of the Site - XXXXX

Number of Users – 10

Existing WAN BW – 2Mbps

Average WAN Utilization during business hour, considering the peaks -> 50% = 1Mbps

Headroom 2Mbps – 1Mbps = 1Mbps.

Considering minimum 20% Buffer of 2Mbps Link to avoid potential QOS packet drops (2048Kbps * 20% = 496Kbps).

Available BW for Cloud based Email and Collaboration Software Deployment = (1024 – 496) Kbps = 528Kbps.

Question / Challenge to the System administration – Is 528Kbps sufficient for new Email and Collaboration software deployment with the given user concurrency number?

The following sample WAN Bandwidth calculator will help system administration for Site Readiness analysis to assess if the available WAN Bandwidth is sufficient or not. If not, then what will be the next level of WAN Bandwidth that Site will be upgraded to. This WAN Bandwidth calculator will be very handy and ready to use for the systems administrations for architecting new Site with correct Bandwidth Sizing.

Note: Access to the Cloud based Email and Collaboration software is recommended to have via Wide Area Network [MPLS or Internet Based VPN + Netbond and Express Route to Cloud Service Provider] for Security reason rather than Site Specific Internet based Cloud Server access which is vulnerable for Enterprise Network.

Table 6: WAN Readiness Analysis for Cloud Based Email and Collaboration Software

Application Name	Per user WAN BW requirement (Kbps)	User # at site	% of concurrency of user #	Concurrent User#	WAN BW requirement (Kbps)
Email Client	20	10	80%	8	160
Chat Client	5	10	50%	5	25
Audio Conference via Chat Client	100	10	20%	2	200
Audio Conference with Screen Share via Chat Client	200	10	20%	2	400
Video Conference via Chat Client	256	10	10%	1	256
Video Conferencing with Screen Share via Chat Client	350	10	20%	2	700
Cloud based Document Management	256	10	30%	3	768
Cloud based File Share Access	128	10	50%	5	640
Delta WAN BW Required					3194

Is the Site Ready?	NO
Total WAN BW Proposed	4Mbps.

Note: Enterprise Organization should also focus on intelligent decision making regarding role out of application – full feature of limited feature deployment. Application role out strategy is directly dependent on the Bandwidth requirement of the Sites. May be for large site full feature application deployment and for smaller sites limited feature application deployment can be strategized to save cost as High BW demand will have high budget requirement.

Limited Application deployment includes – Basic function such as Email Service and Chat Service while full feature application deployment includes –

- Email
- Chat
- File Share
- Audio Conferencing
- Video Conferencing
- Document Management
- Fire Share while on Audio / Video Conferencing

Site Specific user number and application specific user concurrency information should be provided by business to have accuracy and authenticity enhanced for the WAN Bandwidth Calculator.

3.6. WAN monitoring

WAN Monitoring Service is very important and add value in capacity planning. WAN Utilization trend helps by providing greater visibility which is the key enabler for BW upgrade decision.Enterprise organization should focus on two kinds WAN Monitoring Solutions.

a) SNMP Based Monitoring – which will provide WAN Utilisation trend. Time Specific utilization trend will help to understand the business hour vs non-business hour utilization of WAN Link. Proactive alerting can be arranged for the following for faster action to avoid risk of disaster.
- Alerting on WAN Circuit Over Utilisation (75% Utilization – Warning, 80% Utilisation - alarming, 90% Utilisation – Critical.
- Alerting on CPU Over Utilisation (75% Utilization – Warning, 80% Utilisation - alarming, 90% Utilisation – Critical.
- Alerting on Duplex Mismatch on the Router Interface
- Alerting on Temperature – crossing the threshold limit
- Alerting on Network Up / Down (Primary / Backup)
- Alerting on BGP or OSPF Neighbor down
- Alerting on Packet drop on interface
- Alerting on CRC error on the router interface

b) Netflow Monitoring – When WAN Circuit is over utilized, before taking WAN Bandwidth upgrade decision, it is very important to analyse the top talker information. Means identification of the users, top applications which are killing the WAN. Based on that visibility application configuration tuning can be performed. Example – Microsoft Security Compliance Manager (SCM) or other patch management tool can take lots of WAN Bandwidth. File Share may kill the WAN. Based on Netflow Data Analysis, Application deployment strategy can be intelligently fine-tuned based on technical feasibility like – out of office hour deployment, per user WAN Bandwidth limitation etc.

Example of Netflow reporting –
Site Name / ID – XXXX
Router Hostname – YYYY1234
Data Capture Start Date / Time –
Data Capture End Date / Time –

Table 7: Sample Netflow Top Talker / Traffic Report for Greater Visibility

Source IP	Destination IP	Application / Port	Avg. Kbps	Peak Kbps	Total Volume (GB)
10.1.1.15	10.2.2.20	443 HTTPS	120Kbps	1033Kbps	33
10.1.1.34	10.33.2.55	8080 Intranet	550Kbps	789Kbps	29
10.1.1.89	10.39.40.100	80 Internet Proxy	339Kbps	654Kbps	4.5

3.7. Local loop migration

Worldwide technologies are evolving and Ethernet and broadband services and getting faster expansion. Leased Line, Copper based legacy DSL services are not cost effective, Enterprise customer should focus on pushing WAN Service providers for faster adaptation of Ethernet and broadband services to get cost and technology advantage. More Bandwidth means lesser price and shorter time duration of Bandwidth upgrade as in most of the cases it should be soft upgrade rather than arranging new Circuit.

3.8. IP address management

IP address management is one of the crucial elements for Capacity Management. Specially for Public IP address, which requires to be clearly documented with Purpose, Host information etc. and threshold alerting to be set so that procurement of new IP pool can be initiated well in advanced to avoid any last-minute delay in Project Go Live.
Organisation should start with the spreadsheet for IP address Management and gradually move into tool based IP address management solution so that host level and connected switch port level granularity will be available, which host is holding which IP belongs to which site and associated with which switch port – which VLAN membership etc.
For Private IP, it is recommended for large enterprise to use Class A IP address (10.x.x.x/8) while class B (172.16.x.x/12) can be used for mid segment enterprise while Class C is only suggested for small organization with few branch offices. IP address requires to be properly documented with purpose, site information etc. which will be key information to handle Merger and acquisitions to avoid potential IP address Conflict.
For Large Enterprise, there may be 3 verticals of overall IP address management –

- Per Function – this is important for QOS allocation – example
- VOIP / UC Voice Service Ranges (VLAN 5)
- Business LAN IP Segment (VLAN 10)
- WiFi Segment (VLAN 15)
- Fixed IP Device Segment (VLAN 20)
- Production Network Segment (VLAN 25)
- Video Conferencing IP Ranges (VLAN 30)
- Production Network Control IP Segment (VLAN 35)
- Management IP Segment (VLAN 40) CCTV Monitoring Segment (VLAN 45)etc.
- Per Zone – Enterprise organization can operate across the globe. In that case per function IP address will have clear delegation to the specific zones as below –
- America Zone
- APAC Zone
- EMEA Zone

Each Zone will have per function IP pool allocation.

- Per Site –Under each Zone, site specific IP address assignment should happen to map the site specific VLANs with the allocable IP address pool. Fixed IP and DHCP IP address requirement should be addressed. For DHCP IP allocation, redundant DHCP servers are recommended to avoid single point of failure.

3.9. WAN inventory management baselining and benchmarking

WAN Inventory management via tool is one of the elementary tasks to document the details of Circuit including IP address, Site Address – Contact information, POP details, distance from POP, Financial details, Providers details, service level, technical details etc. Based on the WAN inventory, country / Site / Region specific technical / commercial trend will be available as high visible management report. Expenditure for same BW MPLS / Internet circuit for a country will be visible with clarity. This information can be used to setup bench mark for other similar circuit in the country.
Benchmarking can be initiated with the help of 3rd party partner like Gartner to have clarity of cost per bandwidth per country per provider, based on that either best provider can be selected or further negotiation can be initiated with the existing provider to get commercial benefit.

3.10. WAN service level

Wide Area Network Service Level is critical component based on which WAN Solution will be designed. Few KPIs are –

- Availability Requirement – based on which redundancy to be added.
- Latency requirement – Based on which Service Provider needs to be selected.
- Application Performance – Only MPLS solution can provide QOS enabled solution compared to Internet based VPN Solution, as internet based VPN solution is dependent on 3rd party internet, ISP and backbone congestion.
- MTTR and TTR Requirement –How fast line can be restored, hardware can be replaced are important factors that ensure high percent of Site availability. Violation of SLA may have credit back but multiple outage can result negative perception for the customers and application response may not be satisfactory as expected.

Table 8: MPLS Vs Internet Based VPN – Comparative Analysis

KPI ID#	KPI Description	MLPS	Internet Based VPN
1	Application Performance Guarantee	Good	Moderate
2	Latency	Good	Moderate
3	Time to Restore and Hardware Replacement	Good	Moderate
4	End to End ownership of Provider	Good	Moderate
5	Cost	High	Low

3.11. Before time management

For Enterprise Organization, Demand and expectation from business and customers are growing day by day. Timeline has become very critical. Faster service delivery meeting the quality standard and budget has become default requirement. On time Service is just good, aspiration is before time service delivery to reduce last minute risks / surprised. Organization should follow few best practices as below to meet overall project timeline

- Requirement initiation on time
- Feasibility Analysis on time
- Capacity Planning on time
- Getting the quotation on time
- Getting the approval on time
- Ordering on time
- Cancellation [If required] on time
- Communication on time
- Communication on time if there is any dependency of Service Delivery
- Escalate on time
- Plan for Execution on time.

4. Results and discussion

Every Enterprise organization should focus on Management reporting which should include WAN availability, utilization (BW and CPU), SLA to have clear trend which will be the foundation for making constrictive decision in Capacity Planning for WAN Bandwidth Upgrade / Downgrade etc. Also, there should be a clear roadmap for Site Specific WAN Bandwidth requirement to run the required applications to provide clarity to the management how much investment they need to make to have a site go live for either new site or existing site – new application deployment.

WAN Bandwidth Calculator

Sample Application Name	Per User BW (Kbps)	Concurrency %	No Concurrent User	WAN BW Requirement (Kbps)
VOIP / UC Voice	64	0	0	0
Device Based VC	1000	0	0	0
ERP	32	50	5	160
Middleware	32	20	2	64
Intranet	20	30	3	60
Internet	48	30	3	144
Email	20	60	6	120
Chat	5	20	2	10
Chat with Audio Conf	100	10	1	100
Chat with Audio Conf & Screen Share	200	10	1	200
Chat with Video Conf.	256	10	1	256
Chat with Video Conf & Screen Share	350	10	1	350
Share Drive Access	256	10	1	256
AV / OS Patch Management	128	20	2	256
Document Management	128	10	1	128
Handheld Application	40	0	0	0
WAN Bandwidth Required				2104
20% Buffer to avoid QOS Packet Drop				105.2
Total WAN Bandwidth Requirement				**2209.2**

Site Name	XXXX
Number of Users	10

Fig. 2: Site Specific WAN Bandwidth Calculator.

Based on Above Calculation minimum WAN Bandwidth Requirement is 2Mbps for 10 Users site and Maximum WAN BW requirement is 4Mbps for MPLS or Internet for VPN Connection. MPLS will be QOS enabled Service backed by SLA while Internet VPN will have no application guarantee and best effort service from Quality of Service perspective as Internet is uncontrolled.
WAN Bandwidth Roadmap based on number of users at site, total number of users and application specific user concurrency %. Based on the given roadmap as recommended approach IT manager can have greater visibility on the bandwidth requirement and take conscious decision for new site deployment or upgrading WAN Bandwidth as part of Network Readiness due to New Application deployment.

	User No. 20			User No. 50			User No. 100			User No. 150			User No. 250			User No. 500			User No. 1000		
Sample Application Name	Per User BW (Kbps)	Concurrency %	No. of Concurrent User	WAN BW Requirement (Kbps)	Concurrency %	No. of Concurrent User	WAN BW Requirement (Kbps)	Concurrency %	No. of Concurrent User	WAN BW Requirement (Kbps)	Concurrency %	No. of Concurrent User	WAN BW Requirement (Kbps)	Concurrency %	No. of Concurrent User	WAN BW Requirement (Kbps)	Concurrency %	No. of Concurrent User	WAN BW Requirement (Kbps)	Concurrency %	No. of Concurrent User	WAN BW Requirement (Kbps)
VOIP / UC Voice	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Device Based VC	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ERP	32	50	10	320	50	15	800	50	50	1600	50	75	2400	50	125	4000	50	250	8000	50	500	16000
Middleware	32	20	4	128	20	10	320	20	20	640	20	30	960	20	50	1600	20	100	3200	20	200	6400
Intranet	20	30	6	120	30	15	300	30	30	600	30	45	900	30	75	1500	30	150	3000	30	300	6000
Internet	48	30	6	288	30	15	720	30	30	1440	30	45	2160	30	75	3600	30	150	7200	30	300	14400
Email	20	60	12	240	60	30	600	60	60	1200	60	90	1800	60	150	3000	60	300	6000	60	600	12000
Chat	5	20	4	20	20	10	50	20	20	100	20	30	150	20	50	250	20	100	500	20	200	1000
Chat with Audio Conf	100	10	2	200	10	5	500	10	10	1000	10	15	1500	10	25	2500	10	50	5000	10	100	10000
Chat with Audio Conf & Screen Share	200	10	2	400	10	5	1000	10	10	2000	10	15	3000	10	25	5000	10	50	10000	10	100	20000
Chat with Video Conf	256	10	2	512	10	5	1280	10	10	2560	10	15	3840	10	25	6400	10	50	12800	10	100	25600
Chat with Video Conf & Screen Share	350	10	2	700	10	5	1750	10	10	3500	10	15	5250	10	25	8750	10	50	17500	10	100	35000
Share Drive Access	256	10	2	512	10	5	1280	10	10	2560	10	15	3840	10	25	6400	10	50	12800	10	100	25600
Management	128	20	4	512	20	10	1280	20	20	2560	20	30	3840	20	50	6400	20	100	12800	20	200	25600
Document Management	128	10	2	256	10	5	640	10	10	1280	10	15	1920	10	25	3200	10	50	6400	10	100	12800
Handheld Application	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAN Bandwidth Required				4208			10520			21040			31560			52600			105200			210400
20% Buffer to avoid QOS Packet Drop				210.4			526			1052			1578			2630			5260			10520
Total WAN Bandwidth Requirement				4418.4			11046			22092			33138			55230			110460			220920

Fig. 3: Technical Comparison of WAN Bandwidth Requirement Based on Number of Users (Road Map for Future WAN Readiness Dashboard for New Site).

It is also important to have commercial benchmarking per region so that IT Department / Management team should have clear understanding regarding the commercial impact for the proposed WAN Bandwidth for new / existing site, based on the clarity budget can be allocated / approved for future WAN link deployment / BW upgrade.

Site Category	Min WAN BW (Mbps) W/O Voice - VC	Max WAN BW (Mbps) With Voice - VC	Estimated Min Monthly Cost APAC (USD)	Estimated Max Monthly Cost APAC (USD)	Estimated Min Monthly Cost EMEA (USD)	Estimated Max Monthly Cost EMEA (USD)	Estimated Min Monthly Cost AMERICA (USD)	Estimated Max Monthly Cost AMERICA (USD)
XXS - User Number 0-10	2	4	1000	2500	900	2300	800	2000
XS - User Number 11-20	4	10	2500	3000	2300	2800	2000	2500
S - User Number 21-50	10	20	3000	3500	2800	3400	2500	3100
M - User Number 51-100	20	30	3500	5000	3400	4860	3100	4300
L - User Number 101-150	30	40	5000	5500	4900	5400	4300	4700
XL - User Number 151-250	50	100	6000	7500	5900	7300	4800	7500
XXL - User Number 251-500	100	200	7500	8000	7300	7800	7500	8000
XXL - User Number 500+	300	400	9000	10000	8500	10000	8500	9800

Fig. 4: Comparison Table for WAN Bandwidth Requirement Based on the Number of User Estimation of Commercial Impact in Various Zones (Asia, Europe and America).

Following Cost Optimisation initiative to be incorporated as standard best practice guideline –
* For Smaller site – Internet based VPN link can be installed rather than expensive MPLS Link. Where Redundancy required for Smaller site – Dual Internet link can be incorporated for VPN backup.
* Very small site where Service is activated on demand can be integrated with 3G/4G Service.
* WAN Acceleration Service can be adopted to avoid WAN bandwidth upgrade for the site – mainly data centres, country Head office, strategic locations etc.
* Combination of MPLS and VPN should be adapted wherever possible to bring down the overall cost of Backup link. Since Primary MPLS link gets higher SLA and MTTR and remains up most of the time, VPN based backup can provide basic connectivity without QOS.
* If possible Load Sharing of both MPLS line can be used. May not be easily available in most of the links but next generation SD WAN will provide much flexibility when it will be available in the Industry later 2018.

5. Conclusion

It is essential to standardize the WAN Solution to have clear roadmap to the management team and IS organization so that greater visibility will be available which site will require how much WAN bandwidth to you n Number of application with Y number of concurrency and what will be commercial impact to arrange the require WAN Link (MPLS / Non MPLS). This benchmarking will be WAN Cookbook and ready reference for budget allocation for expansion planning of existing site or new site setup.
Out of scope eliminant of the current research

- Generic applications of Enterprise Customers have been Considered.
- Very Specific Industry oriented application software were not in focus.
- Real Bandwidth Hungry applications like SCM patch management for Microsoft or other Vendor OS / Security Patch upgrade has not been considered as WAN traffic during business hour. Following Best Practice – Critical locations should have local Servers and Client should get GB Volume of patches over the LAN rather over the WAN to minimize the impact of the WAN Links.
- Server to Server replications for SCM Patches from Central Data Center Server / Cloud Server to Local Servers should be intelligently Configured to happen during off business hour so that end user's business operations are not impacted due to patch upgrade.
- Legal restrictions of using certain WAN Services / VOIP services has not been considered which is specific to the countries.

The case study is framed based on single provider based managed WAN Services for Enterprise Customers with Global Presence and high level cost analysis. Actual cost may be + or – 10 – 15% depending country / Providers and their WAN technology available to provide basic / Advance WAN Connectivity.
The above out of scope elements can open new horizon for further research opportunities to address future requirement for WAN Standardization and cost optimization initiatives.

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