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Optimisation of Communication Network Based on Supply Chain Management Model

– I S Ghuman*
Research Scholar, School of Management Studies, IGNOU, New Delhi,
21iqroop@gmail.com *https://orcid.org/0000-0001-9268-2229*

– Vishal Nagpal
Alumini IIT Madras and Prolific writer,
vishu73ns@gmail.com *https://orcid.org/0000-0001-9283-7913*

– Anurag Saxena
Professor, School of Management Studies, IGNOU, New Delhi,
anurags@ignou.ac.in *https://orcid.org/0000-0002-3092-3098*

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ABSTRACT

Purpose: This research paper has been pursued with the aim to study correlation among various factors (bandwidth, speed, accuracy, resilience, reliability, interference & installation time), to suggest a model for an efficient communication network (based on Supply Chain Management Model) without any substantial increase in cost, which meets user requirements for different scenarios. The paper attempts to validate a quantification matrix/model of these factors.

Design/Methodology/Approach: Two methods have been adopted for the study. In the first method, a survey from 20 people was carried out to identify the crucial factors and their inter-se priority for an efficient communication network. In the second method, a model of communication network was created and implication of change in user requirement on cost of implementation was studied.

Findings: A standard template cannot be applied for provisioning of communication in various scenarios. The architecture, topology and technology for the network is to be designed specific to the user requirement based on the factors discussed in the paper, namely Time Available for installation of Network, Distances involved, Number of Users and Services Required.

KEYWORDS Network | Supply Chain Management | Communication | Critical Success Factors | Key Performance Indicators

INTRODUCTION

This research paper has been pursued with the aim to study correlation among various factors (bandwidth, speed, accuracy, resilience, reliability, interference & installation time), to suggest a model for an efficient communication network (based on Supply Chain Management Model) without any substantial increase in cost, which meets user requirements for different scenarios. The paper attempts to validate a quantification matrix/model of these factors. In this paper, existing communication network is analyzed to pinpoint the capabilities and limitations of various communication media to suggest a model for communication network for various scenarios. The models of supply chain network and communication network have been compared to identify the crucial success factors of communication network and their implication on cost and time. Similarities of transportation component of supply chain model and communication network have been discussed. Communication networks for businesses, military operations and disaster relief activities have been analysed to draw out similarities in communication requirements of both networks.

***Corresponding Author** (I S Ghuman)

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Information and data flow forms an important component of growth and development of businesses. With the advancement of technology and expanse of data communication, importance/relevance of communication (voice/data/video) has increased multifold in all businesses. Most users adapt themselves to the capabilities and limitations of existing communication services which may or may not be optimum for their requirements. Small variation in the architecture, topology or external factors may have direct/ indirect implication on efficiency of communication network which affects results/profits of the businesses.

Over the years, the users have managed their communication in number of ways, including telephone calls, faxes and electronic data exchanges. More recently, with the advancement of technology, and power of internet, these users are relying on machine to machine information transfer through database servers. The telecommunication industry has seen tremendous development in the recent years and modern communication networks are based on high speed IP routers interconnected with optical backbone, with capabilities of providing integrated services combining voice, video and data. Design Problems for simple communication networks is a complex subject. Finding an optimal solution for realistic size network in a limited time is difficult proposition. There are however, clever designs and randomized approaches that can be combined to find a good solution. Rather same problem can be solved using different methods, enabling a comparison of the solutions as well as the methods. Therefore, optimisation of communication networks has been the subject of numerous research actions. The fundamental step towards an optimised efficient communication network is the network topology. The key issue is designing a network topology with allocated resources so that the user requirements are met, at a minimum cost. Optical Fiber network, Wireless Networks and Satellite Communication are the most common options available to a network planner. Each of the media options mentioned above has its own advantages and disadvantages.

An effective Supply Chain Management (SCM) Model has been found to be useful for optimization of almost all industries in the market. Lack of coordination between supply chain partners may cause uncertainties in demand. Identification of crucial success factors of SCM model has been the key to optimization of resources to meet the demand. Flow of information in a network can be compared/ likened to flow of any product/item/service in a Supply Chain Network (SCN), wherein provision of service 'On Time in Full (OTIF)' is crucial. Disruption in flow of information/ data can cost heavily to the efficiency of a communication network, which is similar to affect of breakages in SCN. High speed, reliability, coverage and security of information are operational requirements of an efficient communication network and therefore also the key indicators. Implementation of measures to meet these requirements has an implication of cost and installation time. Identification of Crucial Success Factors (CSF) of communication network is likely to assist in optimization of resources.

While research papers on "Application of SCM model for improvement of Service and Manufacturing Industry" do exist, no literature/reference was available where SCM model has been applied for identification of factors for optimization of communication networks. The paper required in depth study of research papers on SCN and communication networks. In this paper, models of SCN and communication network have been compared to identify the key success factors. This study is the first attempt to compare SCN with communication network to identify crucial factors. There is no literature available where crucial factors for communication network were determined based on SCM model.

Two methods have been adopted for the study. In the first method, a survey was carried out to identify the crucial factors and their inter-se priority for an efficient communication network. Since the study required detailed knowledge and experience inputs from only selected participants were obtained. Therefore, the sample size for the survey was restricted to 20 persons. It was ensured that the participants are a mix of consumers and service providers to get a balanced view of the requirements. As part of the survey, the users were also requested to give inputs on change in priority of crucial factors based on communication requirements and scenario of the user. In the second method, a model of communication network was created and implication of change in user requirement on cost of implementation was studied. While change in reliability, speed or other requirements cannot be directly correlated to reciprocal increase in cost, attempt has been made to analyse and correlate the two. This study also helped in comparing various media being used for provision of modern communication. Based on a survey and with support of a sample network, these factors have been analysed to understand their implication on cost (Installation and Maintenance) and time for installation of network.

Operational requirements of communication networks for three different scenarios were studied to recommend models for establishing efficient communication networks. Communication requirements of businesses, military and disaster relief operations have been generalized for the purpose of study and may vary for different scenarios based on terrain and specific operational requirements. The research paper suggests optimization of communication network within the existing technologies. In the end, similarities of operational requirements of communication network for military and disaster relief operations have been highlighted so that future study can be carried out in the subject field.

Literature Review

As mentioned earlier, no literature/reference was available where SCM model has been applied for identification of factors for optimization of communication networks. The paper required in depth study of research papers on SCM and communication networks for identification and correlation of crucial success factors and key performance indicators for the two networks.

Supply Chain Management Network

Supply chain management is the coordination of production, inventory, location and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served (Karakadilar, 2015). According to the paper, the supply chain management revolves around production, inventory, location, transportation and information. (MERIT Career Development, 2015).

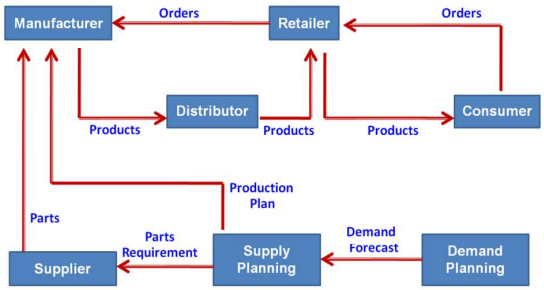

Figure 1: Supply Chain Management Diagram,
(Adapted from Lazarus, 2017, Solve Complex Supply Chain Issues)

There are three steps for aligning a business with the SCM model. First step is to understand the market. The second step is to define the strengths and core competence. The third step is to develop the required supply chain capabilities. Inventory, Manufacturing, Storage Facilities, Information, Pricing, Transportation, Distribution and Supply are key components of Supply Chain Management Model. (Gamme et al., 2015). Cost of inventory accuracy and inventory turnover, transportation, criticality of time, creation of infrastructure and reliability are some of the crucial factors in a SCN (Kumar et al., 2015).

Transportation is a crucial element that drives the performance of SCM model. Together with inventory costs, transportation costs stand for approx. 60 % of the total logistical costs which makes it an important component. There are several transportation related decisions that managers need to consider such as cost for transportation goods, physical network design, service negotiations and information support systems (Tracey, 2004)

S No	Crucial success Factors	Key Performance Indicators
1	Facility/ Infrastructure	Reachability Reliability
2	Communication/ Information Flow	Response Time
3	Inventory accuracy	Wastage Customer Satisfaction
4	Efficient Transportation	Accuracy (On Time In Full) Reliability

Table 1: CSF and KPI for SCM Network
(Adapted from Decelle, 2007)

Communication Networks

A communication network as a SCN is a collection of interconnected nodes which enable voice/data communication between users. These networks facilitate transfer of information over large distances. Businesses use these networks to expand and grow their networks. Capacity, Reliability, Services, Speed and Distance are the factors for consideration while comparing technologies for rollout of communication network. (Mohamed et al., 2015). Installation Time, Cost, User Connectivity, Mobility, Reliability, Speed and Bandwidth, Interference, Security and Quality of service are the characteristics for comparing wireless and wired networks (Kaur, Monga, 2014).

It can be deduced that while communication infrastructure, redundancy, coverage, encryption and dedicated resources are Crucial Success Factors (CSF), high speed, reliability, reachability (coverage), security, response time and cost are the Key Performance Indicators (KPI), (Muthaiyah, 2004).

S No	Crucial Success Factor (Cause)	Key Performance Indicator (Output)
1	Communication Infrastructure	High Speed
2	Redundancy	Reliability
3	Coverage	Reachabilty
4	Encryption/Non Radiation	Secure
5	Dedicated Resources	Response Time, High Cost
6	Installation Time	

Table 2: Identification of CSF and KPI for Communication Network
(Based on Mohamed et al., 2015)

Communication networks are designed to ensure reliable and secure transmission of information without substantial increase in investment in infrastructure. There is variety of communication medium solutions, such as optical fiber cables and UHF communication. Each of the communication medium has its advantages and disadvantages according to its technological characteristics (Ibrahim et al., 2017).

Study of Communication Networks

Communication networks can be optimized by understanding criticality of each factor and modifying its weightage in the network to achieve desired objectives of extended ranges, high mobility, reliability, speed etc. (Gengan, 2002).

Key Factors of Communication Networks

Speed/ Bandwidth (Quality of Service) It is the capacity of communication network to transmit the amount of data from one point to another in a given amount of time. Synonymous with capacity, speed/bandwidth describes the data transfer rate. The main factor affecting the speed is the technology used for data transfer. While fiber optic networks enable high speed connections, Ultra High Frequency (UHF) and satellite networks have limited transfer speeds.

Reachability/Coverage (Terrain/Range) Deployment of adequate resources to ensure coverage of complete area irrespective of terrain and distances involved. Reachability of network is dependent on type of media (OFC/UHF/ Satellite), expanse of operational area and terrain profile. UHF terminals can be used to provide communication up to 25 km, subject to availability of Line of Site. OFC network provides communication up to 80-100 km. However, Satellite Communication does not get restricted by terrain/ranges. (Jafaru et al., 2017).

Services (Voice/Data/Video) Convergence of voice, data and video services on a single device in a seamless manner is an operational requirement for majority of users of communication networks. High speed/bandwidth is essential to ensure quality of service for provision of voice, data and video services to the users in a seamless manner.

Mobility The ability of user to continue to access complete services of the network on the move, irrespective of his location, is called mobility. This crucial service can be provided subject to deployment of adequate resources for coverage of the area within the time available and implementation of latest technologies on mobility management.

Reliability (Disruptions due to Terrain/Weather/ Interference) Reliability is the measure of how often a network is useable. MTBF (Mean Time between Failures) is a measure of the average time a component is expected to operate between failures (Torell et al., 2004). The network failure can be hardware, data carrying medium and Network Operating system. In order to ensure reliability of communication network, the redundancy to be built into networks must be specified, for media as well as network components. While communication over optical fiber cable is reliable, communication over radiating media like UHF/Satellite is susceptible to disruptions due to bad weather/interference.

Security of Data Security is the protection of hardware, software and data from unauthorized access or uncontrolled losses/effects (Bowman et al., 2015). Restricted physical access to computers, password protection, limiting user privileges and data encryption are common security methods. Absolute security is difficult to achieve in practice and may lead to compromise on access or speed. Encryption of data through bulk encryption devices before transmission on network is essential to ensure security of data.

Implication of Key Factors on Cost and Time

Cost of Establishing a Network The cost of Infrastructure development for establishing communication network includes Civil Infrastructure, Power transmission with backup (inverters/ UPS), controlled environment and communication equipment (Servers, Storage, Transmission Towers, Antennas etc.). The cost of infrastructure development is dependent on various factors like services required, coverage, reliability, mobility and scalability. The implication of the factors mentioned above on cost has been discussed in succeeding paragraphs.

Cost of Maintenance The cost of maintenance of communication network includes repair/replacement of equipment, consumption of electricity and skilled manpower for maintenance of network.

Installation Time Time for rollout of communication network will depend on the choice of media, coverage and redundancy. While installation time for Satellite network is negligible, laying of OFC is time consuming.

Transportation of Information In a communication network, time for transportation of information is the most crucial factor as voice and video services require real time communication and no delays can be accepted. Therefore capacity, reliability and redundancy are essential components of a communication network.

Communication Networks and Supply Chain Networks: Dynamics

As discussed earlier, interconnect between supply chain network and communication network requires further study. Comparison of architecture and operational requirements of SCN and communication network has been carried out in Table 3.

S No	Factor	Communication Network	Supply Chain Management Network
1	Manufacturing Cost	No/Limited Cost	High Cost
2	Storage Cost	Low Cost	High Cost
3	Non-Utilisation of Product	No/Limited Monetary Loss	High Monetary Loss due to damage to stocks
4	Transportation	Most Crucial	One of the Components
5	Criticality of Time	Real Time (No Delays)	Not Real Time
6	Infrastructure	Required	Required
7	Reliability	High Reliability Required with No Disruptions	Network can be managed with Limited Disruptions

Table 3: Comparison of Supply Chain Management Model and Communication Network

The architecture of communication network, based on SCM Model is given at Figure 2. Information Processors in a communication network can be compared to manufacturers in commercial networks and data centers can be compared to Ware Houses. Users of communication network are the producers of information (raw material) and also the consumers of information (product).

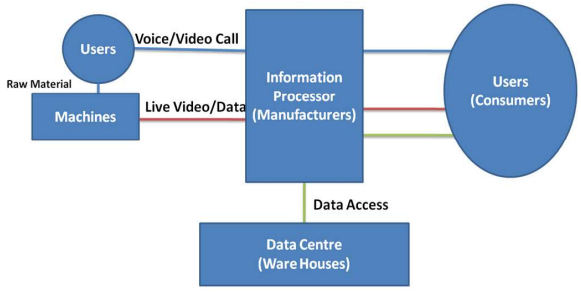

Figure 2: Architecture of Communication Network, (Adapted from Lazarus, 2017 Solve Complex Supply Chain Issues)

It is evident from the comparison of the two networks (Business and Communication Network) that Inventory; Manufacturing, Storage and Non-utilization do not have major implication in a communication network.The major factor of SCM Model, which is applicable to communication network as well, is transportation.Communication network can be compared to the transportation part of the supply chain management model.

S No	Supply Chain Management Network	Communication Network
1	Inventory Turnover	
2	Inventory accuracy	
3	Delivery/Shipment Time	High Speed Data Transfer Reliability Reachability/Mobility Security Services
4	Cash to cash Cycle Time	
5	Warranty Costs	

Table 4: Comparison of Communication Network with Transport Model of SCM Network

Transportation is a key element that drives supply chain performance (Kant, 2014). There are several transportation related decisions that managers need to consider such as cost for transporting goods, physical network design, mode and carrier assignment, service negotiations and information support systems. In the network design one needs to consider whether a shipment from a supplier should be directly shipped or should go through one or several consolidation points. In terms of transportation modes, one need stop decide the mode (rail, air or sea) and all modes have different characteristics. For example transportation by air is an expensive option and leads to increase in cost. However, it allows the company to deliver the products to the customer in a shorter timeframe (Game et al., 2015).

Delivery Reliability, On Time Arrival, User Satisfaction, Transit Time, Damage free shipment, Shipping Accuracy and mode of transport are few of the transportation measures. Transportation Measures mentioned above can be compared with the key factors essential for planning rollout of a communication network. Speed, Reliability, User Satisfaction and Security of data are factors which are common to both the networks.

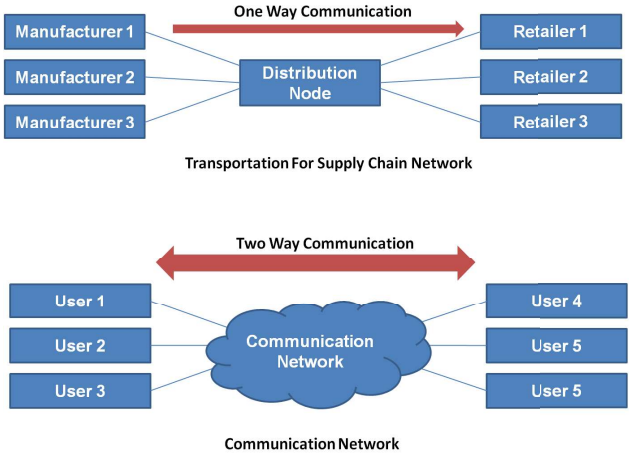

Figure 3: Comparison of Transportation for Supply Chain with Communication

Other Supply Chain Networks

Business is a process by which the exchange of goods, services, capital, technology and knowledge takes place. Globalization has created new opportunities for businesses to increase profits by expanding markets and by allowing wider access to resources (Globalization and Business, Principles of Management), which means that organizations can serve customers across national/state borders through better supply chain management, improved shipping, reduction of trade barriers, centralized financial institutions and enhanced communications. Modernization of communication

technology has been one of the key contributors of expansion of modern business networks. High Speed integrated voice, data and video services are significant for development of businesses. Dramatic development of communication technology has enabled new forms of working patterns (Dudovskiy, 2012).

Disaster Relief Operations are normally related to coping with a calamity, mainly natural and at times man made. Several government and private agencies put in concerted efforts to minimize the loss due to disasters. As per the increasing global trends, natural disasters are set to increase multifold in next 50 years (Thomas, 2007). Communication Systems during disaster relief are crucial. Ensuring strong communication during disaster relief is very important for rescue operations, to locate and give aid, provide access, etc. (Premkumar R., 2014).

Military Forces deploy at a short notice, to conduct surveillance operations over large areas. Enhanced data capabilities are needed for improved situational awareness at multiple levels allowing better coordination. Modern Military Communications networks are being designed to provide rapid connectivity, agility and secure communication. Analysis of common requirements and operational specifications of military communication network suggest that these networks, not only meet the requirement of military operations, border control and Maritime Security communication, but also are suitable for humanitarian assistance and disaster relief efforts.

Research Methodology

Step 1: Survey and Data Analysis

A survey was carried out to examine the importance of key factors for communication network in various scenarios and also to lay down inter se priority of these factors for provision of communication. Due to the technical nature of questions, two type of participants were selected to take part in the survey. The first set of respondents consisted of service providers (communication engineers) and second set consisted of users of communication network during military and disaster relief operations. A total of fifteen persons were interviewed.

As part of first set of questions, the respondents were requested to compare various medias with respect to crucial success factors for communication networks discussed earlier. As part of second set of questions, the respondents were requested to compare various media for their usage for communication network in various scenarios. As part of third set of questions, the respondents were asked to compare the criticality of cost, time and speed for communication network in various scenario. As part of fourth set the respondents were asked to lay down inter-se priority of crucial success factors for communication network for various scenarios.

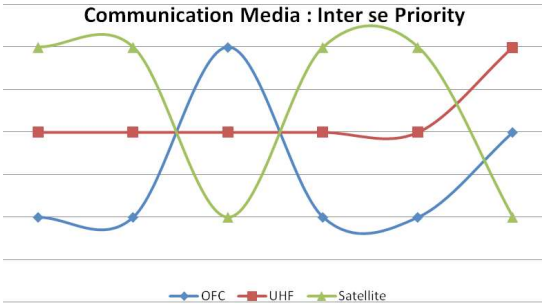

Figure 4: Effect of Choice of Media on Key Factors of Communication Network

S No	Factor	Supply Chain Management	Communication Network Businesses	Communication Network Military	Communication Network Disaster Relief
1	Demand Pattern	Known	Known	Estimated	Not Known
2	Lead Time	Known	Known	Estimated	Zero
3	Infrastructure	Existing	Existing	Existing/ On Wheels	Local Resources
4	Objective	DOTIF	Quality of Service (Max Revenue)	Swift, Reliable and Secure	Swift Communication at Remote Loc
5	Availability of Funds	Sufficient	Sufficient	Limited (No Returns)	Limited (No Returns)
6	Components	Product, Manufacture, Ware houses, Supply chain, Consumers	Data creators & Processors, Analysers, Data Centres, Comn Network, Users	Data Creators & Processors, Data Storage, Comn Network, Users	Data Creators & Processors, Data Storage, Comn Network, Users

Table 5: Comparison of Communication Network in Various scenarios
With Supply Chain Management Model (Adapted from Reddy, 2017 and Ghuman, 2018)

As explained in the graph (Figure 4) generated from the survey inputs, Optical Fiber cable is ideally suited for provision of high speed, secure, reliable and integrated communication. However, satellite communication is more suitable for better mobility and Reachability.

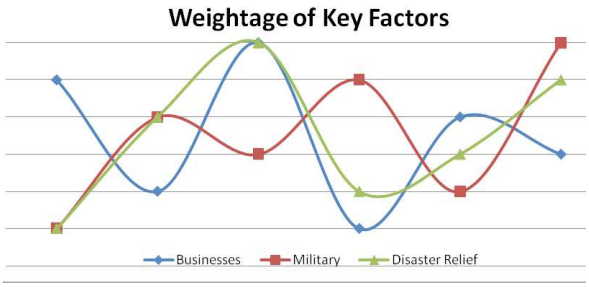

Figure 5: Importance of Key Factors for Different Scenarios

As explained in the graph (Figure 5) generated from the survey inputs, the operational requirements of communication network for the three scenarios are completely different. While security and reachability are crucial for communication network for military, mobility and high speed communication is the requirement of communication network for modern business networks.

Step 2: Simulated Network

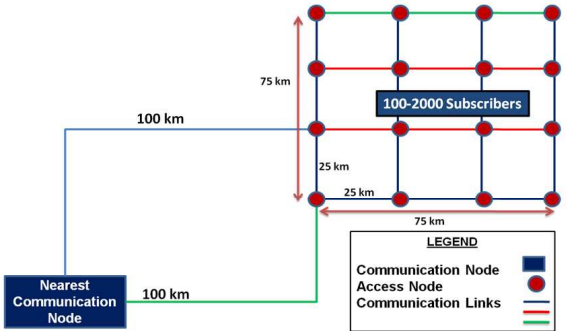

Figure 6: Network Diagram for a Sample Communication Network

For the purpose of the study, it has been assumed that there is a requirement of provision of communication in a remote area of 75 km x 75 km, which is approximately 100km from the nearest communication node. Communication in the area has been planned based on point to point communication links of 25 km (Limit of range of UHF Communication). Network diagram for the simulated network diagram is given at Figure 6. Efficacy of the network was analyzed to determine effect of various factors on cost of provisioning Voice/Data/ Video Communication Services to 100-2000 users operating in the area. Analysis of cost based on services, scalability and ranges involved are discussed in succeeding paragraphs.

S No	Media Type	Requirement		Increased Reliability						High Speed			Mob	Incr Range	Security	No of Users
				100%		200%		300%		STM1	1 G	10 G	Addl Term	200 Km	Encryption Device	2000
		Qty	Cost (Lakhs)	Qty	Cost (Lakhs)	Qty	Cost (Lakhs)	Qty	Cost (Lakhs)	Cost (Lakhs)	Cost (Lakhs)	Cost (Lakhs)	Cost (Lakhs)	Cost (Lakhs)	Cost (Lakhs)	Cost (Lakhs)
1	OFC (km)	475	475	650	650	850	850	1000	1000	1000	1000	1000	1800	2000		2200
2	UHF (Links) (STM1)	27	67	34	85	42	105	48	120	120	960 (80%)	9600 (800%)	1780	1820	Cost of Encryption Devices will be added to the Infra Cost for all Networks	2020
3	Satl 100 Users + Satellite	01 term and 100 users	400	02 term and 100 users	600	03 term and 100 users	800	03 term and 100 users	800	1000 (2MB)	Not Feasible		800 Lakhs			2600

Table 6: Cost Analysis for Establishment of Communication Network. Using Various Media (Based on Estimated Costs)

Based on the network diagram, requirement of the Optical Fiber Cable, UHF and Satellite equipment was calculated. The cost estimates for installation of communication network is based on approximate costs from earlier projects due to non-availability of commercial data. Approximate cost of OFC for 1km is Rs 1 Lakh, cost of two terminals of UHF link is Rs 2.5 Lakh and Cost of one earth stn and 100 terminals is Rs 400 Lakh. Approximated cost of establishing the networks were compared. The reliability of the network was increased by increasing the redundancy and fresh comparisons of cost were made. Also, the implication of increase of numbers of users on the cost was studied. Finally comparison of cost with increase in ranges and mobility was carried out in Table 6.

Step 3: Deductions/Inferences

OFC Network is the most expensive option and takes maximum time for installation. However, large bandwidth, extended ranges and high reliability (less susceptibility to interference/disruption) makes OFC the most suitable option. Therefore, in case time is not at premium, OFC is the preferred media for high bandwidth reliable backbone communication.

UHF/MW is the cheapest (least costly) media for provision of backbone communication with limited bandwidth (32 MB) requirement. However, increase in requirement of bandwidth to 1G, puts it at par with Optical Network and any further increase of data requirement makes it a costly option.

Satellite Communication is the recommended option in case number of users and the requirement of bandwidth (2MB) are limited. Quick installation, high mobility and coverage of remote locations further make Satellite Communication a lucrative option. However, with increase in number of users, the cost of the network increases multifold. Also, vulnerability to inclement weather, limited bandwidth and time lag makes it unviable option for real time applications like voice and video.

As mentioned above, Fiber Optics and UHF communication are ideally suited for high capacity backbone communication, but do not support communication on the move. Mobility for Optical Fiber Cable (OFC) and UHF/MW communication can be achieved by integration of backbone network with Cellular/Radio Communication as Access Network with Backbone Communication.

Conclusion and Recommendations

A standard template cannot be applied for provisioning of communication in various scenarios. The architecture, topology and technology for the network is to be designed specific to the user requirement based on the factors discussed above, namely Time Available for installation of Network, Distances involved, Number of Users and Services Required. Comparison of communication requirement for a commercial network, military network and disaster relief network has been discussed in Table 5.

Communication Network for Businesses High Bandwidth, large number of users and requirement of permanent static infrastructure are the crucial factors. Demand pattern for communication network for businesses is well known through past experience. The objective of the network is to provide Voice, high speed Data and Video communication in an efficient manner without any disruptions. Sufficient time is available for installation of communication network; therefore time of installation of network is not critical. Cost of installation of network can be incorporated as part of the business plan.

Communication Network for Military Communication Secure, reliable and flexible communication systems with adequate redundancy form an integral part of Military communication. The core of the required capability is "communication, anywhere, anytime and with anybody". The essential capabilities required are integrated two way communication on a portable handset with adequate redundancies to obviate failure in operational contingencies. Robust, reliable and survivable communication networks are essential for military communication. The demand pattern for a military requirement is not known but can be estimated based on past experiences. The lead time for installation of network in the area of operation is short. The objective of the communication network in Military is to provide swift, secure and reliable communication to the users.

Communication Network for Disaster Relief. The crucial factors for communication network for disaster relief are short installation time, Reachability and mobility. Although, the number of users of communication network is limited, systems are expected to perform at their best in hostile conditions since human lives are at stake. Past tragedies have like Tsunami in 2011, Sep 11 attacks, Hurricane Katrina have highlighted serious flaws in existing communication network. (Premkumar R., 2014). Scale and nature of each disaster would be different. The demand pattern of disaster affected area is not known, lead time for installation of network is zero and all existing infrastructure is unlikely to be available due to destruction caused by the disaster. Communication network for disaster relief should be easily configurable and scalable to accommodate these requirements. The communication and response in an emergency network would be wireless, real-time, self-powered and having low latency.

Recommendations and Way Forward

Provision of communication can be compared with SCM model. Based on the resources available, the communication network and the services can be optimised by application

of SCM model, to provide best services to meet user requirement. Network Design and choice of technology will be based on operational requirements of the user, funds and time available for rollout of communication network.

Communication network for commercial use are based on high speed cellular technology, with capability to provide sophisticated services combining voice, data and video. IP based modern communication Networks are ideally suited to meet the communication requirements of commercial networks. The core network consists of combination of OFC and static UHF links as high speed backbone and cellular network for providing communication on the move.

There are large number of similarities in operational requirements for communication for military and disaster relief (Sabbagh, 2015). In both these cases, real-time communication voice and data communication is required in an area which is devoid of any existing communication infrastructure. Therefore, provision of OFC based communication network with high speed data may not be feasible ab initio.

Communication Network for operational requirement of a military network is recommended to be based on UHF communication (No disruptions), on the wheels (Short Deployment Time), integrated with nearest node of existing OFC based strategic backbone network (High Capacity Backbone). Combat net radio or Cellular (Portable Handsets) based access network to ensure mobility. Satellite Network to be used as an overlay (Redundancy) to ensure reliability and provide communication to remote location (Reachability) devoid of coverage of existing network.

As discussed earlier, there is similarity in communication requirement of military and disaster relief operations. During the initial phase of Disaster Relief Operations, Satellite based mobile briefcase/handheld terminals are the recommended means for restoring immediate communication in a disaster affected area. However, with the restoration of basic services like electricity, cellular communication integrated with UHF terminal is the recommended solution. During the recovery phase, the network can be upgraded to Optical network to cater for voice/data requirement (high bandwidth/speed) for the users.

Similarity of operational requirements of communication network for military operations and disaster relief mandates further examination of the suitability of military communication model for provisioning of communication for disaster relief operations.

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Annexure 1

Submission Date	Submission Id	Word Count	Character Count
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Urkund Analysis Result

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https://www.researchgate.net/publication/308702156_Supply_chain_management_best_practices_A_case_of_humanitarian_aid_in_southern_Africa

Instances where selected sources appear: 3

Reviewers Comment

Review 1: This paper has compared SCM model with a complex network like communication network. Feasibility of improvement of communication network based on SCM model will require further research.

Review 2: With the development of modern communication networks and transportation of data as a product, the scope of further research can be expanded to include more number of users from different type of networks. .

Review 3: As per deductions made by the author in the paper, there is a stark resemblance between operational requirement of military and disaster communication network. This deduction can be further explored to recommend measures for utilization of resources of military communication for disaster management.

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EDITORIAL BOARD EXCERPT At the time of submission, the paper had 2% of plagiarism which is an accepted percentage as per the norms and standards of the journal for the publication. As per the editorial board's observations and blind reviewers' remarks the paper had some minor revisions which were communicated on timely basis to the authors (IS, Vishal & Anurag) and accordingly all the corrections had been incorporated as and when directed and required to do so. The comments related to the manuscript are related to the theme "**Optimisation of Communication Network**" both subject-wise and research-wise. Optimization can benefit business situations which involvecostly assets.The telecommunication industry has seen tremendous development in the recent years. Modern communication networks are based on high speed IP routers interconnected with optical backbone, with capabilities of providing integrated services combining voice, video and data etc. Finding an optimal solution for realistic size network in a limited time is difficult proposition.Therefore, optimisation of communication networks has been the subject of numerous research actions. Overall the paper promises to provide a strong base for the further study in the area. After comprehensive reviews and editorials boards remarks the manuscript has been decided to categorise and publish under the "**Case Study Based Paper**" category .