The design of physical and logical topologies for wide-area WDM optical networks

by

Albert Dirk Gazendam

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Die ontwerp van
fisiese en logiese topologieë vir
wye-area WDM optiese netwerke
deur
Albert Gazendam

Promotor: Prof. F. W. Leuschner
Departement: Elektriese, Elektroniese and Rekenaar-Ingenieurswese
Graad: Meester in Ingenieurswese (Elektronies)

Sleutelwoorde

wye-area optiese netwerk; golflengte-verdelingsmultipleksering; ontwerpmetodologie; verkeeropknapping; aangepaste gravitasie-model; nodusweging; ekonomiese aktiwiteit; netwerkbestuur; netwerkbetroubaarheid; loknodus; multi-vlak netwerkmodel; Ward-skakeling; intra/inter-groep verkeersverhouding; groepering

Opsomming

Die doelstelling van hierdie verhandeling is om the faktore te ondersoek wat die ontwerp van wye-area golflengte-verdelingsmultipleksering ("WDM") optiese netwerke beïnvloed. Wye-area netwerke word aangebied as kommunikasie netwerke wat in staat is om spraak sowel as data kommunikasie oor groot geografiese areas te bewerkstellig. Hierdie netwerke strek gewoonlik oor 'n hele land, streek of selfs kontinent.

Die vinnige ontwikkeling tot volwassenheid van WDM tegnologie oor die laaste dekade het kommersieel suksesvol geblyk en moedig nou die ontwikkeling van vaardighede in die ontwerp van optiese netwerke aan.

Die fundamentele doel van alle kommunikasie-netwerke en tegnologieë is om die verbruiker se behoeftes te bevredig deur die lewering van kapasiteit oor gedeelde en beperkte infrastruktuur. Inagname van die besigheidsaspekte verbonde aan kommunikasieverkeer en die opknapping daarvan is belangrik, indien die gebruiker se behoeftes verstaan wil word ten opsigte van die kwaliteit en beskikbaarheid van dienste en toepassings. Uitgebreide kommunikasie-netwerke benodig komplekse bestuurstegnieke om hoë vlakke van betroubaarheid en winsgewendheid te verseker.

'n Geïntegreerde metodologie word voorgestel vir die ontwerp van wye-area WDM optiese netwerke. Die metodologie maak gebruik van fisiese, logiese, en virtuele topologieë, saam met roetering en kanaalaanwysing ("RCA") en groeperingsprosesse om objektiwiteit aan die ontwerpsproses te verleen. 'n Nuwe benadering, gebaseer op statistiese groepering met die Ward-skakeling as ooreenkomsmate, word voorgestel vir die bepaling van die hoeveelheid en posisies van die loknodusse op die multi-vlak netwerkmodel. Die invloed van die geografiese verspreiding van netwerkverkeer, en die intra/intergroep verkeersverhouding word in ag geneem deur gebruik te maak van aangepaste gravitasie-modelle en die innoverende weging van netwerknodusse.

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Keywords

wide-area optical network; wavelength division multiplexing; design methodology; traffic grooming; modified gravity model; node weighting; economic activity; network management; network reliability; hub node; multi-level network model; Ward linkage; intra/inter-cluster traffic ratio; clustering

Summary

The objective of this dissertation is to investigate the factors that influence the design of wide-area wavelength division multiplexing (WDM) optical networks. Wide-area networks are presented as communication networks capable of transporting voice and data communication over large geographical areas. These networks typically span a whole country, region or even continent.

The rapid development and maturation of WDM technology over the last decade have been well-received commercially and warrants the development of skills in the field of optical network design.

The fundamental purpose of all communication networks and technologies is to satisfy the demand of end-users through the provisioning of capacity over shared and limited physical infrastructure. Consideration of the business aspects related to communications traffic and the grooming thereof are crucial to developing an understanding of customer requirements in terms of the selection and quality of services and applications. Extensive communication networks require complex management techniques that aim to ensure high levels of reliability and revenue generation.

An integrated methodology is presented for the design of wide-area WDM optical networks. The methodology harnesses physical, logical, and virtual topologies together with routing and channel assignment (RCA) and clustering processes to enhance objectivity of the design process. A novel approach, based on statistical clustering using the Ward linkage as similarity metric, is introduced for solving the problem of determining the number and positions of the backbone nodes of a wide-area network, otherwise defined as the top level hub nodes of the multi-level network model. The influence of the geographic distribution of network traffic, and the intra/inter-cluster traffic ratios are taken into consideration through utilisation of modified gravity models and novel network node weighting.

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List of abbreviations

3R	regeneration with re-timing and re-shaping
ANSI	American National Standards Institute
APS	automatic protection switching
ARPA	Advanced Research Projects Agency (United States)
ATM	asynchronous transfer mode
BER	bit error rate
bps	bits per second
BT	British Telecommunications
CAD	computer aided design
CWDM	coarse wavelength division multiplexing
DARPA	Defense Advanced Research Project Agency (United States)
dB	decibel
DCS	digital cross-connect system
DS	digital system (PDH signal)
DWDM	dense wavelength division multiplexing
EDFA	erbium-doped fiber amplifier
EON	European Optical Network
FDM	frequency division multiplexing
FTIR	Fourier transform infrared
Gbps	gigabits per second
GHz	gigahertz
GUI	graphical user interface
IP	Internet protocol
ISP	Internet service provider
ITU	International Telecommunications Union
LAN	local area network
LED	light emitting diode
MAN	metropolitan area network
MB	megabyte
Mbps	megabits per second
MEMS	micro electro-mechanical systems
MONET	multi-wavelength optical networking
MPLS	multi-protocol label switching

NAS	network access station
NE	network element
NGN	next generation networking
NP	nondeterministic polynomial time
NSF	National Science Foundation (United States)
OADM	optical add-drop multiplexer
OC	optical channel
OEO	optical-electronic-optical
ONN	optical network node
OR	optical receiver
OT	optical transmitter
OXC	optical cross-connect
PD	photo diode
pdf	probability distribution function
PDH	plesiochronous digital hierarchy
PIN	positive-intrinsic-negative
PoP	point-of-presence
PNNI	private network-network interface
PSTN	public switched telephone network
QoS	quality of service
RCA	routing and channel assignment
ROI	return on investment
SADM	SONET/SDH add-drop multiplexer
SDH	synchronous digital hierarchy
SEM	scanning electron microscope
SHR	self-healing ring
SNR	signal-to-noise ratio
SONET	synchronous optical network
STM	synchronous transport module
STS	synchronous transport signal
Tbps	terabits per second
THz	terahertz
vBNS	very-high speed backbone network service
VoD	video-on-demand
VoIP	voice-over-IP
WADM	wavelength add-drop multiplexer
WAN	wide-area network
WDM	wavelength division multiplexing
WIXC	wavelength interchanging cross-connect
WRN	wavelength-routed network
WSXC	wavelength-selective cross-connect
WWW	World Wide Web

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