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Signalling and Scheduling for Efficient Bulk Data Transfer in Circuit-switched Networks

by

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Supervisor: Prof. D.G. Kourie

Co-supervisors: Prof. M. Veeraraghavan and Prof. J. Roos

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Summary

The number and size of files transferred over the Internet is sufficiently significant to warrant the investigation of faster and more efficient mechanisms for their transfer. This research begins by comparing the performance of circuit-switching and TCP/IP (which is most commonly used in the Internet) when bulk data is transferred. Experimental and analytical analysis suggests that circuit-switching is indeed better suited for bulk data transfer than TCP/IP.

Circuit-switching suffers from the drawback that connections at rates higher than DS0 (64Kbps) can only be obtained in provisioned mode. For circuit-switching to be usable for bulk data transfer, it should support on-demand circuits at much higher data rates, for example OC1 (51.84Mbps) to OC768 (40 Gbps). A signalling protocol has been designed to be implemented in hardware (thus providing high throughput). It enables the setup of high-bandwidth on-demand circuits in Time Division Multiplexing (TDM) networks. An accompanying routing protocol to be implemented in software is also designed. Further, design decisions are considered for a transport protocol that enables the reliable transfer of bulk data over a circuit-switched connection.

When transferring bulk data over a connection-oriented network that implements preventative congestion control mechanisms, the connection has a deterministic holding time that can be computed from the file size, data transfer rate and propagation delays.

With the knowledge of connection duration it is possible to move away from the current blocking mode of operation (where a call is blocked when a switch does not have sufficient resources to handle it) and to implement a queueing mode of operation where connections are scheduled. By scheduling connections it is possible to reply to a connection request with a later start time if the required resources are not available at the time of the request.

Two scheduling schemes have been designed. Simulations show that at 70% loading, these schemes offer start time delays that are up to 85% smaller and channel utilization of up to 37% larger than a simple queueing mode of operation where call holding times are ignored when connections are set up.

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Opsomming

Die hoeveelheid en grootte van lêers wat tans oor die Internet versend word is noemenswaardig. Om hierdie rede is 'n ondersoek geloods op soek na meer doeltreffende meganismes vir die versending van massa data. Hierdie navorsing begin deur die werkverrigting van *circuit-switching* te vergelyk met díe van TCP/IP (wat tans die mees algemene protokol is vir data versending oor die Internet). Eksperimentele en analitiese ondersoeke suggereer dat *circuit-switching* wel meer geskik is vir massa data versending as TCP/IP.

In *circuit-switched* netwerke is konneksies van slegs DS0(64Kbps) op aanvraag beskikbaar. All konneksies hoër as DS0 moet voorlopig bespreek word en word gewoonlik opgestel met die hulp van menslike interaksie. Vir *circuit-switching* om 'n noemenswaardige invloed te hê op massa data versending is daar 'n vereiste dat die netwerke konneksies teen baie hoër snelhede op aanvraag opgestel kan word. Byvoorbeeld, konneksies van OC1(51.84Mbps) tot OC768(40Gbps) gaan 'n baie groter invloed hê op die spoed van massa data versending as DS0 konneksies. 'n Protokol om konneksies op te stel (*signalling protocol*) is ontwerp om in apparatuur ge-implementeer te word. Deur die protokol in apparatuur te implementeer word die hoeveelheid konneksies wat per eenheid tyd opgestel kan word meer as wanneer 'n protokol gebruik word wat in programmatuur implementeer is. Hierdie protokol maak dit moontlik om konneksies vanaf OC1 tot OC192 op aanvraag in 'n TDM netwerk op te stel. 'n Saamgaande roeteringsprotokol (*routing protocol*), geteiken vir programmatuur implementasie, is ook ontwerp. Verder is opsies oorweeg vir 'n transport protokol wat betroubare versending van massa data oor 'n *circuit-switched* konneksie sal waarborg.

Wanneer massa data versend word oor 'n konneksie-geöriënteerde netwerk wat voorkomende meganismes vir kongestiebeheer implementeer, het die konneksie 'n deterministiese tydsduur wat bereken kan word vanaf die hoeveelheid data, die spoed van die konneksie en die totale vertragings tussen die twee nodes wat data uitruil.

Met die kennis van die tydsduur van die konneksie is dit moontlik om weg te beweeg van die huidige hantering van konneksies waar 'n konneksie geblok word indien daar op enige stadium van opstelling nie genoeg hulpbronne is om die konneksie te kan hanteer nie. Dit is nou moontlik om konneksies te skeduleer. Deur konneksies te skeduleer is dit moontlik om 'n versoek vir 'n konneksie te beantwoord met 'n later begintyd indien daar nie genoeg hulpbronne beskikbaar is wanneer die versoek arriveer nie.

Twee skeduleringskemas is ontwerp. Simulasies van die skemas wys dat teen 70% lading, die skemas vertraging in begintyd van konneksies verlaag met tot 85% en die benutting van kanale verhoog met tot 37% wanneer die skemas vergelyk word met 'n eenvoudige skema waar tydsduur ignoreer word tydens konneksie opstelling.

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Acronyms

ATM Asynchronous Transfer Mode

CAC Connection Admission Control

CL Connectionless

CO Connection oriented

ICMP Internet Control Message Protocol

IETF Internet Engineering Task Force

IP Internet Protocol

OSPF Open Shortest Path First

PDH Plesiochronous Digital Hierarchy

PSTN Public Switched Telephone Network

QoS Quality of Service

RIP Routing Information Protocol

SCTP Stream Control Transmission Protocol

SDH Synchronous Digital Hierarchy

SONET Synchronous Optical Network

TCP Transmission Control Protocol

TDM Time Division Multiplexing

TOS Type of Service

TTL Time To Live

UDP User Datagram Protocol

WDM Wavelength Division Multiplexing