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Summer exam

TTM4150 INTERNET NETWORK ARCHITECTURE

TTM4150 NETTARKITEKTUR I INTERNETT

14. August/august 2010

Kl. 0900 - 1300

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No remedies.

Results will be ready within 3 weeks.

E: English
Glance over all pages before you start answering the exercises.
Take care to share your time between the exercises.
It is better to answer a little on all the exercises than to answer a lot on a few.

If you feel there is a lack of information to solve an exercise, state the assumptions you make.

N: Norsk/Norwegian
Se raskt over hele oppgavesettet før du starter å besvare oppgavene.
Pass på å fordele tiden mellom oppgavene!
Det er bedre å svare litt på alle oppgavene enn å svare mye på noen få oppgaver.

Dersom du føler informasjon mangler for å løse oppgaven, angi de antakelser du gjør deg.

Ex/Oppg 1 Internet architecture/ Internett arkitektur

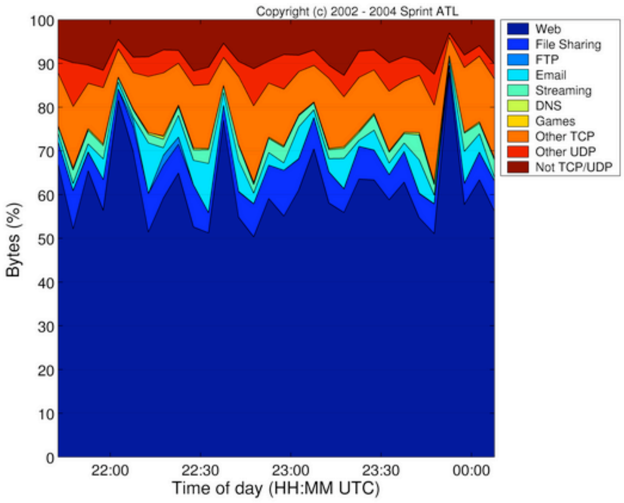
(a) **E:** The top level Internet architecture goal was an effective technique for multiplexed utilization of existing interconnected networks. A second level goal was "**The Internet must support multiple types of communications service.**" How does the original Internet architecture satisfy this second level goal?

N: Det primære målet til Internettarkitekturen var "an effective technique for multiplexed utilization of existing interconnected networks**"** Et sekundært mål var "**The Internet must support multiple types of communications service**." Hvordan tilfredsstiller den originale internettarkitekturen dette målet?

Dumb network with intelligence at the edge
End-to-end service in the transport layer and above
Different end-to-end transport protocols offer different service

(b) **E:** The figure to the right shows Internet application breakdown. In traffic measurements, which protocol fields need to be evaluated to present the graph in the figure?

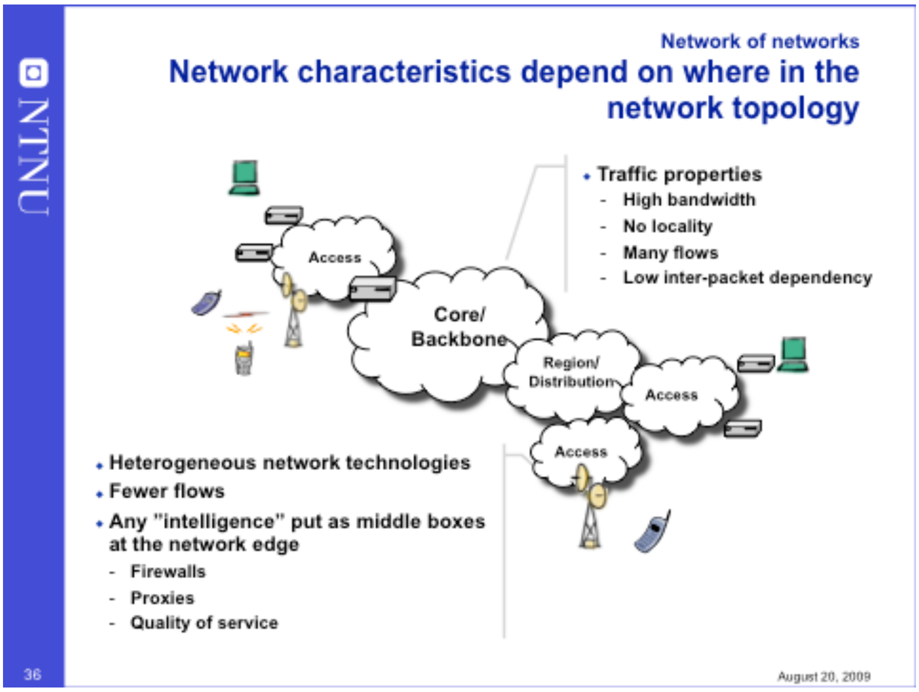
N: Figuren til høyre viser fordeling av Internettapplikasjoner. Hvilke protokollfelt må evalueres i trafikkmålinger for å framstille grafen i figuren?



IP protocol field for type of protocol, IP length field for length of packet, transport layer port fields for application well known ports. Not expected for full score: If bytes are the application message and not the IP packet we also need IP header len and TCP offset (header length).

(c) **E:** Shortly describe the network and traffic characteristics in both the access network and in the network core.

N: Beskriv kort nettverks- og trafikkarakteristikken i både aksessnettet og i kjernenettet.



Network of networks

Network characteristics depend on where in the network topology

- Traffic properties
  - High bandwidth
  - No locality
  - Many flows
  - Low inter-packet dependency

- Heterogeneous network technologies
- Fewer flows
- Any "intelligence" put as middle boxes at the network edge
  - Firewalls
  - Proxies
  - Quality of service

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August 20, 2009

(d) **E:** Table 1 shows the forwarding table for a router with 4 network interfaces. Table 2 lists the destination addresses of 4 different packets. Give the outgoing interface for each of these packets.

N: Tabell 1 viser videresendingstabellen i en ruter med 4 nettverksgrensesnitt. Tabell 2 gir destinasjonsadresser for 4 ulike pakker. Angi hva som blir utgående grensesnitt for hver av pakkene.

Table/Tabell 1

Destination network	Interface
192.168.4.0/16	E1
192.168.4.14/28	E2
192.168.4.16/28	E3
192.168.4.17/24	E4

Table/Tabell 2

Destination address
192.168.4.70
192.168.4.8
192.168.4.28
192.168.1.1

E4,E2,E3,E1

(e) **E:** Can session mobility be handled by the routing protocol?
If so, what are the limitations?

N: Kan sesjonsmobilitet håndteres av en rutingprotokoll?
Hvis ja, hva er svakhetene?

Updates and granularity of router table entries.

(f) **E:** IPVPN is a virtual private network based on internet technology.
Briefly describe two ways of provisioning IP based VPNs and include the description of one implementation technology for each of them. Which IPVPN and why is more suitable for an ad-hoc network?

N: IPVPN er et virtuelt privat nettverk basert på internetteknologi.
Beskriv kort to ulike måter å etablere (”provision”) IP-baserte VPN og inkluder beskrivelsen av en implementeringsteknologi for hver av dem. Hvilket IPVPN og hvorfor er best egnet i et ad-hoc nettverk?

Provder provisioned and customer provisioned.

1. Customer provisioned

- *Customer edge routers managed by private network administrator*
- *VPN handled in customer premises equipment*

2. Provider provisioned

- *Network provider provisions and remotely manages the customer edge devices*
- *Based either on tunneling between customer premises equipment, or handled in network equipment*

*In an ad-hoc network with a dynamic network topology customer edge tunnelering is more suitable. E,g IPsec/**GRE**/IPinIP*

Ex/Oppg 2 Multicast / Multikast

(a) **E:** Describe the Reverse Path Forwarding (RPF) check. What is the purpose of such a mechanism?

N: Beskriv ”Reverse Path Forwarding (RFP) check ”. Hva er motivasjonen for en slik mekanisme?

A packet is forwarded only if it arrives on the interface on the shortest path back to the source. Motivation: to avoid loops.

(b) **E:** Table 3 lists the incoming interface and source address and destination address of 4 packets. Use the routing table given in Table 1 in exercise 1. What is the outgoing interface when RPF check is enabled?

N: Tabell 3 angir inngående ”interface”, kildeadresse og destinasjonsadresse for 4 pakker. Bruk Tabell 1 i oppgave 1. Hva blir utgående” interface” når RPF check er slått på?

Table/Tabell 2

Incoming interface	Src address	Dst address
E1	192.168.4.2	192.168.4.16
E1	192.168.3.11	192.168.4.11
E3	192.168.4.17	192.168.4.15
E1	192.168.3.11	192.168.2.1

RPF fail, E2,E2, reject incoming = outgoing

(c) **E:** What is the relationship between the Internet Group Management Protocol (IGMP) and the multicast routing protocol PIM-SM?

N: Hva er forholdet mellom protokollen Internet Group Management Protocol (IGMP) og multikast rutingprotokollen PIM-SM?

IGMP signals to an edge router that there are end systems interested in a group on one or more of the interfaces of the edge router. Using PIM-SM the edge router signals to connect to the distribution network.

(d) **E:** Why is a source-specific multicast routing protocol less vulnerable to misconfiguration of multicast addresses?

N: Hvorfor er en kildespesifikk multikast rutingprotokoll mindre sårbar for feil i konfigurering av multikastadresser?

Multicast IPv4 addresses are temporary. There is a possibility for address collision or misconfiguration. In a source specific network, the multicast address is only used locally within the source. The source unicast address is used when indexing the multcast routing table. Misconfiguration in other nodes will not affect this.

Ex/Oppg 3 Mobility and transport/ Mobilitet og transport

(a) **E:** An enterprise is multi-homed between two different ISP. Both accesses are active and carry traffic. The enterprise runs mobile IPv4. One of the ISP offers to run the enterprise's Mobile IP home agent (HA) in its network.
What is your recommendation? Describe why.

N: Et selskap er "multi-homed" mellom to ulike ISPer. Begge aksessene er aktive og bærer trafikk. Selskapet benytter mobil IPv4. En av ISPene tilbyr å kjøre selskapets mobil IP hjemmeagent (HA) i sitt nettverk.
Hva er din anbefaling? Beskriv hvorfor.

The offer is of no value, as the home agent must be able to intercept all packets to the address the HA represents. Using multihoming, only packets from one address range can be intercepted. In addition the HA can not intercept packets initiated within the enterpris´s internal network.

(b) **E:** Describe briefly how mobility can be handled at the transport layer.

N: Beskriv kort hvordan mobilitet kan håndteres på transportlaget.

We need a transport protocol offerering a new fixed identifier.
1. Either based on new protocols: No retrofit to existing protocols
2. Alternativ to adapt existing protocols (one needs to be described)

- *Extensions to TCP (e.g proxy)*
- *M – UDP (essentially retrans over wireless by a proxy)*
- *Mobile Stream Control Transmission Protocol (MSCTP)*
- *Datagram Congestion Control protocol (DCCP) extentions*

A common problem for both is the corresponding node initiation of communication with the mobile node.

(c) **E:** The cumulative acknowledgement in TCP serves many purposes. Describe shortly which role the TCP cumulative acknowledgment plays in each of reliability, flow control and congestion control.

N: TCP kumulativ kvitteringsmekanismen tjener mange hensikter. Beskriv kort hvilken rolle TCP kumulativ kvittering spiller i forhold til pålitelighet, flytkontroll og metningskontroll.

Reliability: *TCP error control use the ACK to signal the next expected byte, i.e. it acknowledges the reception of all lower numbered bytes.*
Flow control: *use the ACK in calculating how the receiver window can be advanced: EffWin = MaxWin - (LastByteSent - LastByteAcked)*
Congestion control: *Use received ack to increase the congestion window*
Additive increase: CongestionWindow += Increment,
*Increment = (MSS * MSS)/CongestionWindow*
Slow start: increment congestion window with 1 MSS for each acknowledgement

(d) **E:** The question "What is the appropriate sending rate for the current network path?" is relevant in the beginning of each TCP connection. How does TCP get an answer to this question?

N: Spørsmålet ”Hva er passende senderate for gjeldende nettverkssti?” er relevant i starten av hver TCP-forbindelse. Hvordan får TCP svaret på dette spørsmålet?

TCP congestion control: adapt to changes in available capacity.
Slowstart is the congestion control component at beginning of each connection.
Introduces a new variable at sender `Congestion window` that limits the sender rate.
Slow start increases congestion window exponentially. Objective: To faster (exponentially) decide available capacity in network than doing an incremental increase of congestion window. Start by setting CongestionWindow = 1 MSS. Double CongestionWindow each RTT (increment with 1 MSS for each acknowledgement)

(e) **E:** The underlying motivation for DCCP (Datagram Congestion Control Protocol) is to avoid congestion collapse. Describe for which applications, and why the use of DCCP is intended.

N: Den underliggende motivasjonen for DCCP (Datagram Congestion Control Protocol) er å unngå ”congestion collapse”. Beskriv for hvilke applikasjoner og hvorfor DCCP er ment.

DCCP is intended for applications (Audio, internet telephony, multiplayer games) that currently use UDP: large or long-lived flows of unreliable datagrams. UDP preferred due to TCP's connection set-up delay, state, and reliability.
Traffic mix is changing towards long-lived non-congestion-controlled flows. To avoid congestion collapse needs built-in congestion control also for such flows.

Ex/Oppg 4 Miscellaneous / Diverse

(a) **E:** Can the IntServ signaling protocol RSVP (Resource ReSerVation protocol) be used together with multicast distribution? Motivate your answer.

N: Kan signaleringsprotokollen RSVP (Resource ReSerVation protocol) i IntServ benyttes sammen med multikast distribusjon? Begrunn ditt svar.

Yes, filter + JOIN on RESV messages makes it possible to use RSVP when several answers back to a source.

(b) **E:** What are the main disadvantages of IntServ (Integrated Services). Discuss these related to IntServ used in a wireless ad-hoc network.

N: Hva er de største svakhetene ved IntServ (Integrated Services)? Diskuter disse relatert til bruk av IntServ i et trådløst ad-hoc nettverk.

Scalability due to state. However, wireless networks are small, so this is no issue. Links are relative low capacity, so limited number of lfows that will share a link.
IntServ ned to be supported by all nodes. Paths will be changing if the nodes are mobile.

(c) **E:** In an ad hoc network the five nodes (A;B;C;D;E) are all within receiving range of each other. The nodes run the reactive protocol AODV (Ad hoc On demand Distance Vector), and no node has transmitted any traffic. How many protocol packets will be transmitted in association with establishing a path between A and E?

N: I et ad-hoc nettverk er de fem nodene (A;B;C;D;E) alle innefor "receiving range" av hverandre. Nodene kjører den reaktive protokollen AODV (Ad hoc On demand Distance Vector), og ingen av nodene har sendt noe trafikk. Hvor mange protokollpakker vil bli sent i forbindelse med at det etableres en sti (path) mellom A og E?

Each node will send RREQ once. Due to time outs, node E will await answering until each node has sent RREQ, i.e. 4 RREQs and 1 RREPLY.

(d) **E:** What is the major advantage of using geographic routing for unicast traffic in an ad hoc network?

N: Hva er den største fordelen ved å bruke geografisk ruting for unikast trafikk i et ad-hoc nettverk?

Do not need a seperate routing protocol.

(e) **E:** The regular routing protocol OSPF (Open Shortest Path First) and the proactive ad hoc routing protocol OLSR (Optimized Link State Routing) use different packet formats and link metrics. What is another main difference in how the two protocols distribute protocol packets?

N: Rutingportokollen OSPF (Open Shortest Path First) og den proaktive rutingprotokollen for ad-hoc nettverk OLSR (Optimized Link State Routing) har forskjellige pakkeformat og måleenhet for linkkostnad. Hva er en annen hovedforskjell i hvordan de to protokollene distribuerer protokollpakker?

In OSPF all link state announcements from all *nodes are flooded. In OLSR only topology messages from MPR will be flooded. OSPF has in addition database synchroniztion.*