NTNU
Norges teknisk-naturvitenskapelige universitet
Institutt for telematikk

Kontakt under eksamen/Contact during exam

Name: Kjersti Moldeklev
Tel: 91314517

TTM4150 NETTARKITEKTUR I INTERNETT

TTM4150 INTERNET NETWORK ARCHITECTURE

August 8, 2013
0900 - 1300

Ingen hjelpemidler/No remedies.

Sensuren faller innen 3 uker/Results will be ready within 3 weeks.

N: Norsk/Norwegian
Se raskt over hele oppgavesettet før du starter å besvare oppgavene.
Pass på å fordele tiden mellom oppgavene!
Noen av svarene krever en dypere analyse enn for eksamensoppgaver fra tidligere år. For hver oppgave er det angitt maksimal poengsum **(p)** som reflekterer forventet arbeidsbelastning.

E: English
Glance over all pages before you start answering the exercises.
Take care to share your time between the exercises.
Some of the questions in this exam require a more in-depth analysis. For each question, there is a max score **(p)** assigned to reflect the expected amount of work.

Oppgave/Exercise 1 Arkitektur/Architecture

(a) **(6p)**

N: Ende-til-ende (e2e) argumentet siteres ofte som designprinsippet for Internett. Hvorfor er e2e-prinsippet mindre relevant i dagens design av Internett?

E: The end-to end (e2e) argument has been considered as a major design principle for Internet. Why is the e2e principle less relevant as a design principle for the current Internet?

The communication is not e2e but relies more and more on intermediate servers. New services like content delivery, multicast, security services, NAT all rely on servers somewhere in the network. ISP and government performing activities such as taxation, surveillance and censorship also tend to place servers somewhere in the network.

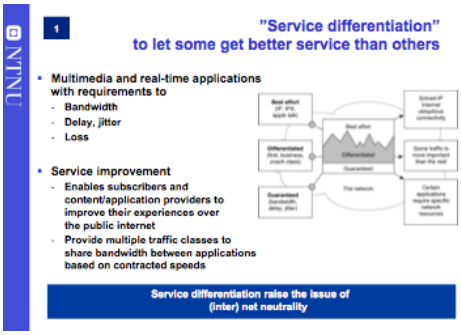
(b) **(6p)**

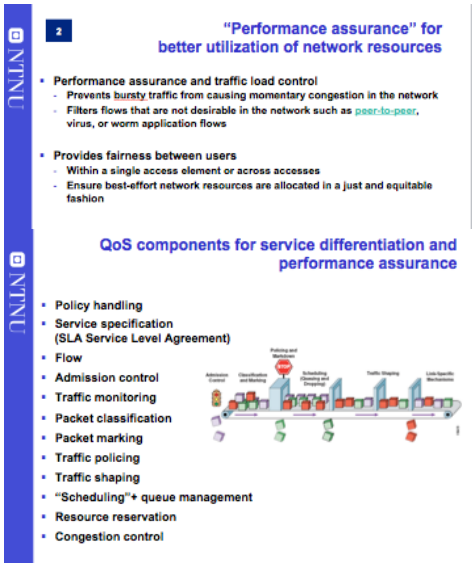
N: Post og teletilsynets retningslinjer for nettnøytralitet definerer at "Internettbrukerne har rett til en internettilknytning fri for diskriminering med hensyn til applikasjonstype, tjenestetype, innholdstype og hvem som er avsender eller mottaker." Dette er en forpliktelse som kommer i tillegg til at blokkering av (lovlig) trafikk for individuelle brukere ikke skal forekomme.

Hvordan er det mulig for en tjenestetilbyder å diskriminere mellom ulike tjenester som en kunder aksesserer?

E: The Norwegian Post and Telecommunication Authority approach to net neutrality defines that "Internet users are entitled to an Internet connection that is free of discrimination with regard to type of application, service, content or based on sender or receiver address." This non-throttling commitment comes in addition to a non-blocking commitment of (legal) individual user traffic.

How is it possible for a service provider to discriminate between different services that a customer accesses?





(c) **(4p)**

N: Ordet "tussle" benyttes for å beskrive motsetninger mellom parter med divergerende interesser i internettmiljøet. Gi et eksempel på en "tussle" med hensyn til design av framtidens internett.

E: The word “tussle” is used to describe the ongoing contention among parties of the Internet milieu with conflicting interests. Give an example of a tussle applying to the design of the future Internet.

A prime example is anonymity. The government needs identity to prosecute and investigate crime, while concerns for freedom of speech tend to favour a design providing anonymity. Examples are spammers vs those who would control them, merchants who need to know who buyers are and buyers who use untraceable e-mail addresses, and between those who want to limit access to certain content and those who try to reach it.

(d) **(6p)**

N: "Content-Centric Networking (CCN) architecture" har to typer PDUer (protocol data units): interest og data. Hva er hensikten med interest PDUene og hvordan prosesseres disse i en CCN-ruter?

E: The Content-Centric Networking (CCN) architecture has two types of PDUs: interest and data. What is the purpose of the interest PDUs and how are they processed in a CCN router?

Interest data packets convey the interest in a particular object. Interest packets set up a path from requester to a source of data.
The router receives an interest. If the object specified in the Interest is cached at the router the object is sent to the router that forwarded the Interest. If an interest in the same object has been received previously, the data structure is updated to include the pointer back to the forwarding router of the interest. If the interest is the first for this particular router to an object, a pointer back to the forwarder is stored together with the interest itself. A copy of the interest is forwarded to one or more routers closer to a potential source for the object.

Oppgave/Exercise 2 Internet adresser/adresses

(a) **(4p)**

N: Figur 1 viser reduksjonen av internett IPv4 adresser hos de ulike internett registratorene (RIR). Kommenter figuren og spesielt linjen til RIPE NCC (Network Coordination Center) som betjener regionen Europa og Midt-Østen.

E: Figure 1 shows the IPv4 address run down of regional internet address registries (RIRs). Comment on the figure and specifically on the line of RIPE NCC (Network Coordination Center) that serves the region of Europe and the Middle East.

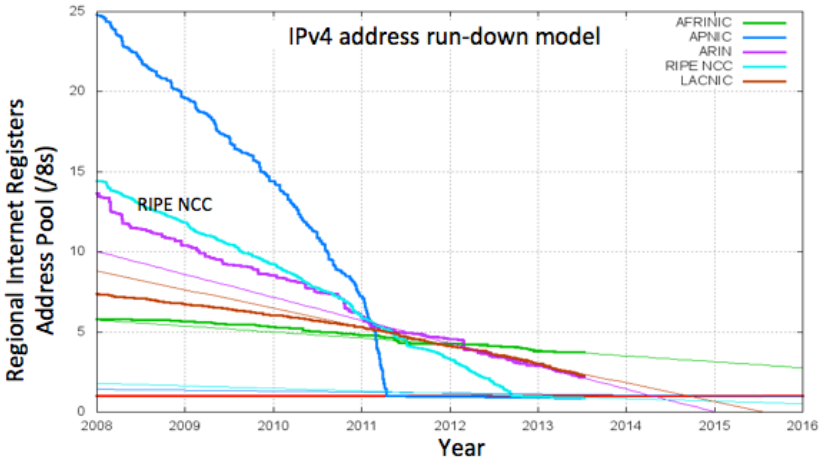


Figure 1. RIR IPv4 address pools

Figure shows the run out of IPv4 addresses in the operating network. APNIC was the the first RIR to run out of addresses. The region of Europe and the Middle East has been the next to run out.

(b)

(4p)

N: Figur 2 viser sentral allokering av Internet addresser hos IANA (Internet Assigned Numbers Authority). Fra linjen lengst mot høyre synes det som den nye adresseplanen (CIDR Classless Inter-Domain Routing) ville gi 2-3 års ekstra tid til å vurdere en framtidsrettet måte for å møte behovet for flere IP adresser.

Beskriv kort to andre viktige Internett-teknologier som gjorde slik at Internett adresserommet overlevde lenger enn år 2002 som var det man forventet i 1993.

E: Figure 2 shows the central allocation of Internet addresses by IANA (Internet Assigned Numbers Authority). From the right-handed line it seams as if the new address plan (CIDR Classless Inter-Domain Routing) would give 2 or 3 years of additional time to work on a longer-term approach to the need for more IP addresses.

Briefly describe two other important Internet technologies that made the Internet address space live longer than the year of 2002 as was expected in 1993.

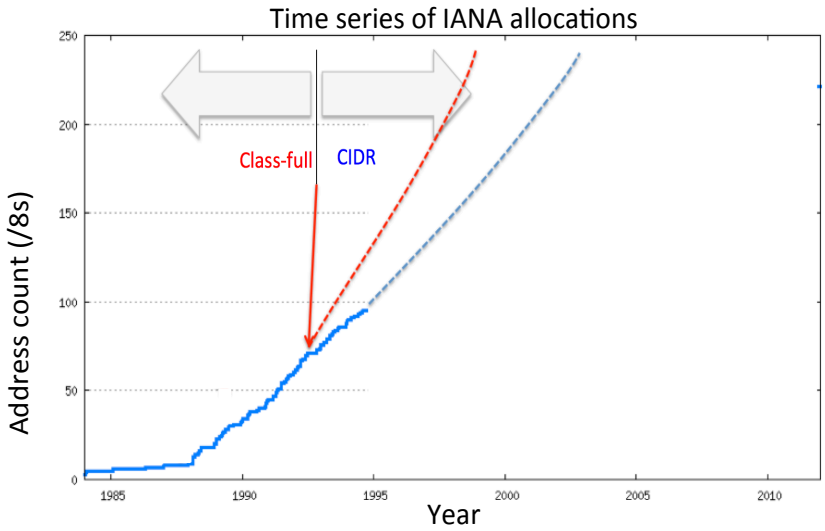


Figure 2. IANA IP address allocations

Network Address Translators (NATs), allowed a collection of devices to share a single public IP address. DHCP (Dynamic Host Configuration protocols) allowed for time-based "rental" of IP-addresses.

(c) **(6p)**

N: I IPv4 har både unikast og multikast adresser. Angi en likhet mellom disse to adressetypene, og angi hovedforskjeller utover at den ene adressetypen benyttes for unikast, den andre for multikast kommunikasjon.

E: In IPv4 there are both unicast and multicast addresses. Give one commonality between these two address types, and state the major differences beyond the fact that one is for unicast and the other is used for multicast communication.

Both are 32 bits long.
Unicast addresses tend to be permanent allocated. They are allocated in a structured fashion to allow routing aggregation. They describe an endpoint location, and are part of a flow identifier.
Multicast addresses tend to be temporary and are not assigned in a structured fashion. They cannot be aggregated and describe a session, not and endpoint.

Oppgave/Exercise 3 Mobilitet og ruting/ Mobility and routing

(a) **(4p)**

N: Med hensyn til mobilitet hva er den største utfordringen i hvordan IPv4 adresser er definert?

E: With respect to mobility what is the main challenge in how IPv4 addresses are defined?

An IPv4 address is used both as an identifier and as a locator. When the location changes, the identifier of a flow also must change.
Also credit if answer lack of aggregation, redirection.

(b) **(6p)**

N: Hva er likheten og hovedforskjellen mellom en mobilitetsprotokoll på nettverkslaget og på transportlaget?

E: What is the main difference between a mobility protocol at the network and at the transport layer?

Both provide translation between the identifier and the locator. However, the network layer has a server that will facilitate setting up the session, i.e a server that can map to a locator for the first packet in a flow. The solutions at the transport level assume that the session is up and provides mechanisms to facility change in the locator.

(c) **(6p)**

N: Hva er hovedforskjellene mellom inter- og intradomene rutingprotokoller?

E: What are the main differences between inter and intra domain routing protocols?

***Inter-domain routing**: interconnection of ASes (autonomous system/domain) (e.g. BGP) and routing between the domains. Interdomain routing provides chains of AS that lead to a network prefix. Focus is connectivity and not shortest path as with*

***Intra-domain routing**: interconnection of subnets and routing within an AS. Intra-domain ignores the routes outside the routing domain. It can either be distance vector, or link state. (Distance vector provides routing tables with distances to destinations. Link state maintains a topology map of all links within the domain and calculates shortest paths.)*

(d) **(6p)**

N: For et trådløst ad-hoc nettverk beskriv hvordan signalleringskostnaden (signalling overhead) endres for den proaktive rutingprotokollen OLSR (Optimized Link State Routing) og den reaktive protokollen AODV (Ad-hoc On-demand Distance Vector) når tettheten av noder øker. Anta et konstant antall noder i nettverket, og et konstant trafikkmønster for flytene.

E: In a wireless ad-hoc network describe how the signalling overhead for the proactive routing protocol OLSR (Optimized Link State Routing) and the reactive protocol AODV (Ad-hoc On-demand Distance Vector) changes when the node density increases. Assume constant number of nodes in the network and a constant traffic patterns for the flows.

OLSR sends periodic messages. Each node sends Hello, so the node density does not affect the overhead Hello messages. As the density increases while the number of nodes remains the same, the average path decreases and more nodes select the same MPR. The number of MPR will therefore decrease, and the number of Tc messages will decrease. Overall the signalling overhead will decrease.

AODV only sends overhead when a path is needed. It floods the network so all nodes transmit a packet when a flow is established. Since the traffikk pattern and number of nodes remain constant, the signalling overhead as a first approximation will remain constant. This answer is sufficient for full score. As already explained, the average path will be reduced with increased node density. The number of RReply will therefore be reduced, so there will be a slight decrease in signalling overhead.

Oppgave/Exercise 4 Transportlaget/ Transport layer

(a) **(6p)**

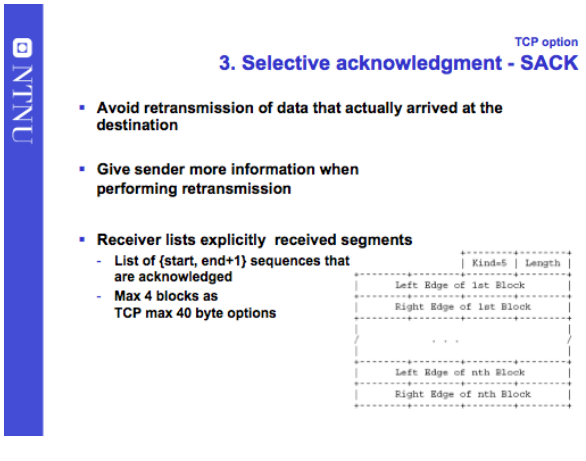
N: Reordning av pakker og bitfeil reduserer TCP-ytelsen i et satellittnettverk, hovedsakelig fordi det fører til overestimering av metning i nettverket. I satellittnettverk med retransmisjon på linklaget og med flerveis ruting er reordning av pakker vanlig. Satellittnettverk har dessuten gjennomgående høy propagasjonsforsinkelse.

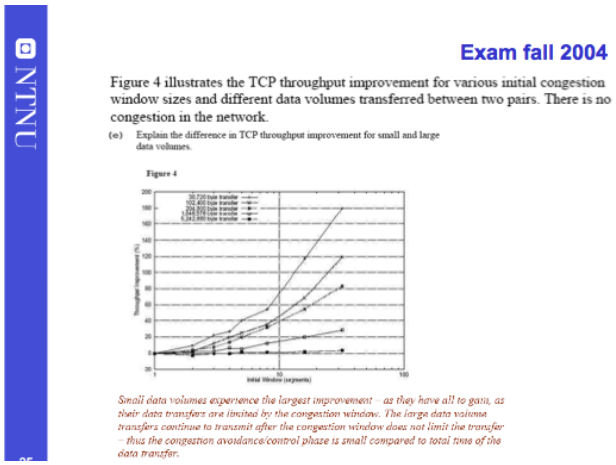
Beskriv to ende-til-ende mekanismer som kan benyttes for å øke ytelsen til HTTP request/response meldinger over en satellittlink.

E: Reordering and corruption of packets decrease the TCP performance of a satellite network, mainly because it leads to overestimation of the congestion in the network. In satellite networks where there are link level retransmissions and multipath routing, packet reordering is common. In addition, satellite networks have in general a high propagation delay.

Describe two end-to-end mechanisms that can be used to increase performance of HTTP-request/response messages traversing a satellite link.

Eg SACK, increased initial window size for flow-start.





(b) **(6p)**

N: TCP forbindelses-oppdeling er illustrert i Figur 3. En ende-til-ende TCP-forbindelse deles opp i to TCP-forbindelser for å skjerme et satellittnettverk med høy forsinkelse eller feilrate fra resten av nettverket.

Tegn protokollstakken i endesystemene, i Gateway noden og i Router noden.

E: TCP connection splitting is illustrated in Figure 3. An end-to-end TCP connection is divided into two TCP connections to shield a high-latency or lossy satellite network from the rest of the network.

Draw the protocol stack in the end systems, in the Gateway and in the Router node.

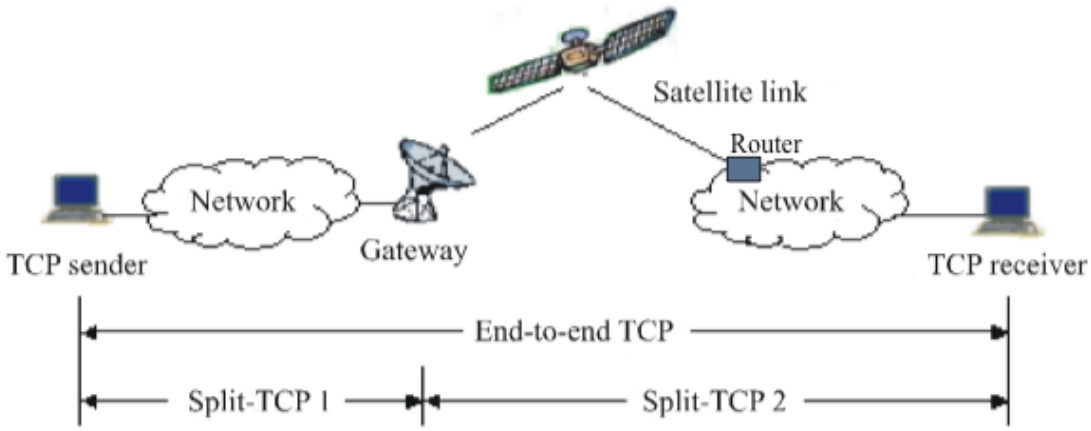
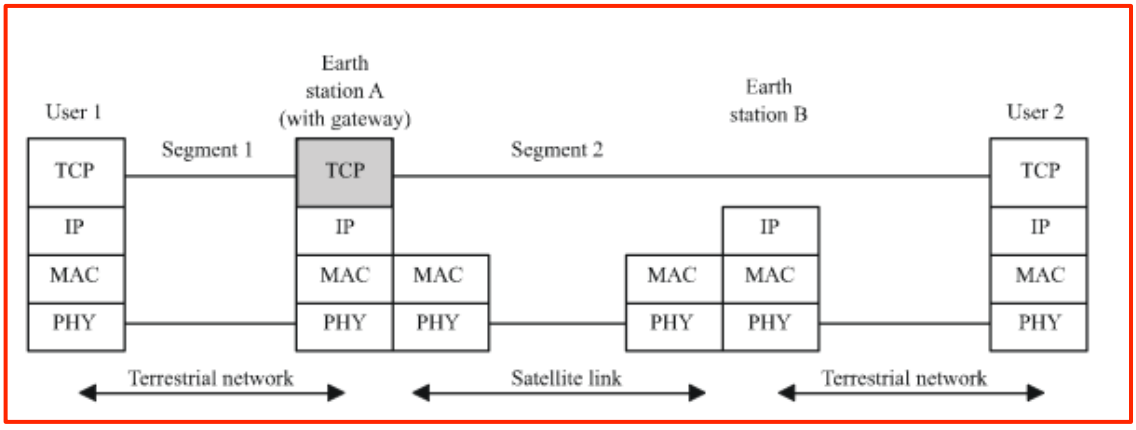


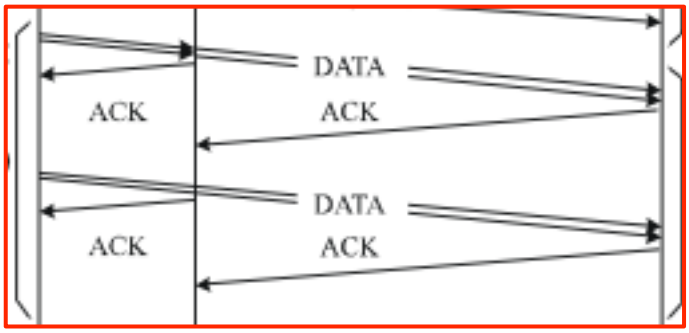
Figure 3. TCP connection splitting



(c) **(4p)**

N: Tegn et pakke sekvensdiagram av datafasen i TCP-forbindelsene.

E: Draw a packet sequence diagram of the data phase of the TCP connections.



Oppgave/Exercise 5 Diverse/Miscellaneous

(a) **(6p)**

N: Hva er ulikheten i funksjonalitet mellom PIM-SM og PIM-DM (protocol independent multicast - sparse/dense mode)?

E: What is the difference in terms of functionality between PIM-SM and PIM-DM (protocol independent multicast - sparse/dense mode)?

Both use soft state and the forwarding state is refreshed every period. PIM-DM establishes a tree per source. The source periodically floods the network so new receivers can receive packets. Those that are not interested signals the lack of interest and the distribution tree is pruned.
In PIM-SM the end router signals interest in a group towards an RP or the source and the distribution tree is formed based on the interest packets. The distribution tree can either be shared or source specific.

(b) **(4p)**

N: Rettigheter til distribusjon av innhold blir gitt for bestemte geografiske regioner. For å vurdere hvilken region en bruker kommer fra benytter flere innholdsdistributører brukerens IP-adressen som nøkkel til en geo-database.

NRK har rettighet for distribusjon av innhold i Norge. Forklar hvordan og hvorfor du kan få tilgang til nrk.no dersom du er på ferie i utlandet og maskinen din har en IP-adresse som ikke viser tilhørighet til Norge?

E: Content distribution rights are given for specific geographic regions. To evaluate the region of a user, several content distributors use the IP-address as a key to a geo-database.

NRK has content distribution rights for Norway. Explain how and why you can get access to nrk.no if you are on vacation abroad and you machine has an IP-address not being registered in Norway?

A VPN tunnel makes the end system have an IP-address of the home network address allocation.

(c) **(8p)**

N: "Prefix hijacking" er ulovlig overtakelse av grupper med IP-adresser gjennom å korrumpere Internet rutingtabeller. Beskriv kort hvilken protokoll som er relevant og hvordan en slik overtakelse kan finne sted.

E: Prefix hijacking is the illegitimate takeover of groups of IP addresses by corrupting Internet routing tables. Shortly describe which protocol is relevant and how such a takeover may take place.

Prefix hijacking can occur deliberately or by accident if BGP announces:
that an AS originates a prefix that it does not actually originate.
a more specific prefix than what may be announced by the true originating AS.
that it can route traffic to the hijacked AS through a shorter route than is already available, regardless of whether or not the route actually exists.
(One of the reasons should be mentioned.)