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TTM4150 NETTARKITEKTUR I INTERNETT

TTM4150 INTERNET NETWORK ARCHITECTURE

December 14, 2012
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) **(4p)**

N: Ble Internett protokollen, IP, laget for framtidens teknologier? Begrunn ditt svar.

E: Was the Internet Protocol, IP, designed to accommodate future generation of technologies? Justify your answer

The IP protocol was designed primarily for multiplexed utilization of exiting interconnected networks (the high level goal). (Second level goal: The architecture must accommodate a wide variety of network technologies.) Since it had very few requirements on underlying network technologies, it was also to a large extent future proof.

(b) **(4p)**

N: Beskriv hvordan en regional nettverksoperatør kan tilby sine småkunder en global IP-basert tjeneste samt global aksess til kundenes web-tjenere.

E: Describe how a regional network provider can offer its small customers a global IP-based service and global access to the web servers of the customers.

Provide global addresses to customers and have peering agreements (national, international) to exchange routing information between autonomous systems, and providing DNS-entry of the web-servers of the customers.

(c) **(4p)**

N: Enhver kunde som vil ha total redundant Internett-aksess må ha sitt eget domene og utveksle informasjon med sine (mer enn en) ISPer (Internet Service Provider). Hvilken informasjon er det snakk om, og hva er utfordringen med slik multi-homing?

E: Any customer who wants to achieve truly redundant Internet access has to have its own domain and exchange information with its more than one ISPs

(Internet Service Provider). What is the relevant information, and what is the challenge by such multi-homing?

Routing information about the subnets of the customer. Multi-homing for increased scalability is a scalability challenge on the network: too many route entries in the default free zone.

(d) **(4p)**

N: Å etterfølge «end-to-end» prinsippet påvirker selve innovasjonsprosessen. Beskriv hvordan.

E: To keep to the end-to-end principle has an impact on the innovation process itself. Describe this effect.

E2E states that functionality needed end-to-end must be implemented in the end systems: innovation does not depend on the relationship with network providers. It is an open process that can be done on an individual basis/purely by the application service provider.

(e) **(4p)**

N: I de siste årene har det vært en betydelig økning i innovasjon av nye applikasjoner for operativsystemet Android sammenliknet med innovasjonsgraden for mobiltelefoner som bruker proprietære operativsystemer. Diskuter om der er likheter mellom de mekanismene du diskuterte i forrige oppgave og de du mener driver innovasjoner av nye applikasjoner for operativsystemet Android.

E: In the last few years there has been a substantial increase in innovation of new applications for the Android operating system compared to the level of innovation related to mobile phones using a proprietary operating system. Discuss whether there are similarities in the mechanisms discussed in the previous questions and the ones you believe drive the innovation of new applications for the Android operating system.

The mobile devices had fairly closed operating systems tying the innovation process closely to the mobile device manufactures. With the Android OS the application design is opened for anybody. This is closely related to the end-to-end argument. The only reason for implementing applications in the network is to improve the performance of the services.

Oppgave/Exercise 2 Adressering og Ruting/ Addressing and Routing

(a) **(4p)**

N: Gitt de to adresseområdene 128.39.64.0/18 og 128.39.95.0/18.

Overlapper disse helt eller delvis, eller er de fullstendig separate? Begrunn svaret ditt.

E: Given the two address ranges 128.39.64.0/18 and 128.39.95.0/18. Do they overlap, partially overlap or are they completely separate? Justify your answer.

They overlap completely since bits 0-17 are identical.

(b) **(4p)**

N: Er der forskjell i hvordan rutere håndterer IPv4 og IPv6 pakker? Begrunn svaret ditt.

E: Is there a difference in how routers treat IPv4 and IPv6 packets ? Justify your answer.

The routers forward both types of packets based on longest prefix matching. However, a router can fragment an IPv4packet, but not an IPv6 packet.

(c) **(6p)**

N: Beskriv forskjellene mellom de to rutingsprotokollene OSPF (Open Shortest Path First) og OLSR (Open Link-State Routing).

E: Describe the differences between the two routing protocols OSPF (Open Shortest Path First) and OLSR (Open Link-State Routing).

OSPF is a unicast link-state routing protocol. All nodes announce their link states by flooding link state packets of their links. OSPF may have a hierarchy by utilizing areas.
OLSR is an ad-hoc routing protocol. Only a subset of the links is reported and only a subset of the nodes floods the topology messages.

(d) **(6p)**

N: BGP er en "path vector" protokoll. Beskriv kort hvilken informasjon BGP utveksler med sine likemenn (peer), og gi noen eksempler på linkkostnader som intradomene rutingprotokoller benytter.

E: BGP is a path vector protocol. Shortly describe the information BGP exchanges with its peers, and give some examples on routing metrics that intradomain routing protocols use.

BGP exchanges network reachability information with other BGP systems, Reachability information is the list of traversed AS's to get to a network prefix. BGP announces local networks, other reachable networks (transit AS) and other route information.

IGP cost of links: Path length/number of hops, Bandwidth, Line cost, Reliability, Bit errors, Delay, Load, Queue length, CPU load, Packets per sec and … combinations

Oppgave/Exercise 3 Ad-hoc and multicast

(a) **(4p)**

N: Et trådløs ad-hoc nett bruker den «reactive protocol « AODV (Ad-hoc On-demand Distance Vector). Gitt et scenario hvor utstrekning er konstant og frekvensen av etablering av nye flyter også er konstant. Hva skjer med «signalling overhead» når antall noder i nettet øker.

E: A wireless ad-hoc network uses the reactive protocol AODV (Ad-hoc On-demand Distance Vector). In a setting where the area of the network is constant and the frequency of flow establishment remains constant. What happens to the signalling overhead as the number of nodes in the network increases?

The overhead of AODV increases as the number of nodes increases since each new flow establishment will require each node to broadcast a route request.

(b) **(4p)**

N: I multikast-arkitekturen er der to typer protokoller: protokoller for håndtering av grupper (feks. IGMP Internet Group Management Protocol) og protokoller for opprettelse og vedlikehold av distribusjonstrær (feks. PIM-SM Protocol Independent Multicast Sparse Mode). Det finnes en JOIN PDU (Protocol Data Unit) i begge. Beskriv med ord disse to JOIN PDUene.

E: In the multicast architecture there are two types of protocols: protocols for group management (e.g. IGMP Internet Group Management Protocol) and protocols for set-up of tree distribution and management (e.g. PIM-SM Protocol Independent Multicast Sparse Mode). There is a JOIN PDU (Protocol Data Unit) in both. Using words describe both JOIN PDUs.

IGMP JOIN is used by the user to signal interest in a group towards the designated router. In PIM-SM the designated router participates in the multicast tree distribution routing protocol by sending a JOIN towards the rendezvous router.

(c) **(4p)**

N: I PIM-SM hvorfor er det vanskelig å etablere distribusjonstrær som spenner over flere administrative domener (AS domains). Er det noen mekanismer i IPv6 som kan gjøre det mulig å etablere trær over flere AS domener?

E: In PIM-SM why is it difficult to establish distribution tree across

administrative domains (AS domains). Are there any mechanisms in IPv6 that can be used to facilitate trees across domains?

The RP (rendezvous point) is configured per domain, so the distribution tree will not cross domains. In IPv6 there are proposals to code the RP address as part of the multicast address, so any designated router can send the JOIN message to RP in other domains and the distribution trees can cross domains.

(d) **(8p)**

N: Multikast, med distribusjonen etablert enten ved hjelp av «sparse mode» protokoller som PIM-SM (Protocol Independent Multicast Sparse Mode) eller «dense mode» protokoller som PIM-DM (Protocol Independent Multicast Dense Mode) og «content centric networking» (CCN) er eksempler på «publish-subscribe» nettverk. Sammenlign de tre alternativene med utgangspunkt i «publish-subscribe».

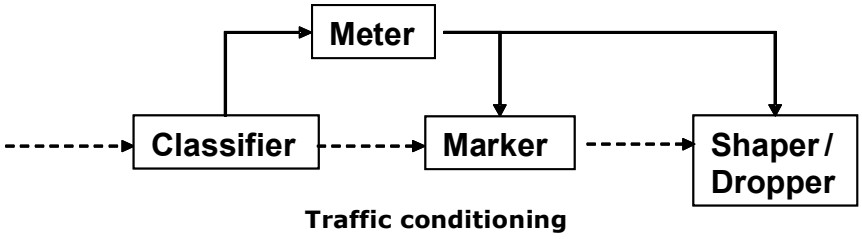
E: Multicast with the distribution established either through sparse mode protocols like PIM-SM (Protocol Independent Multicast Sparse Mode) or dense mode protocols like PIM-DM (Protocol Independent Multicast Dense Mode) and content centric networking (CCN) can be considered publish-subscribe type of networking. Compare the three alternatives from a publish-subscribe point of view.

In sparse mode the designated router signals on behalf of the user interest towards the source of the content. In dense mode the source pushes the content towards potential designated routers. In CNN objects are pushed along paths established by interest packets, very similar to what is done in sparse mode.

Oppgave/Exercise 4
Tjenestekvalitet og metningskontroll/ Quality of service and congestion control

N: En DiffServ trafikkhåndterer består av elementer som vist i figuren under.

E: A DiffServ traffic conditioner consists of elements as shown in the figure below.



(a) **(4p)**

N: Hvordan og hvorfor blir «traffic classification» utført?
E: How and why is traffic classification performed?

Traffic classification classifies packets into classes to give the packets its correct "per-hop behavior"/traffic conditioning. There are two types of packet classifiers:

- *The value of the DSCP (DiffServ Code Point)/Traffic class as a behavior aggregate*
- *Multi-field classification selecting packets based on a combination of more header fields, eg IP src/dst address, IP src/dst port number, protocol id, type of service field (TOS) for IPv4, flow identifier for IPv6*

(b) (4p)

N: TCP bruker «flow control» for å sikre at sender ikke sender mer the mottaker er i stand til å motta. Hvilke protokoll «header fileds» and hvilke tilstandsvariable hos sender blir brukt og hvordan blir de brukt.

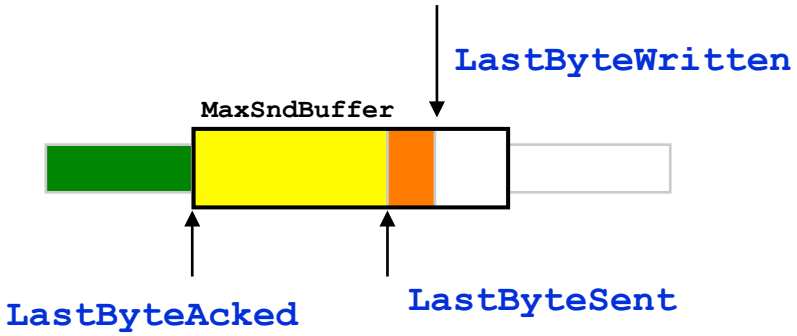
E:TCP uses flow control to assure that the sender is not sending more than the receiver is capable of processing. Which protocol header fields and which state variables are used at the sender, and how are they used?

The sender uses the receiver-announced

- *TCP window size to regulate the maximum number of bytes the sender can transmit before waiting for an acknowledgment.*
- *acknowledgement to advance the edge of the sliding window (LastByteAcked).*

The sender side sliding window consists of the following state variables in addition to the LastByteAcked

- *LastByteSent is sequence number of last byte sent*
- *LastByteWritten is sequence number of last byte written from the application to kernel space*
- *MaxSendBuffer is the buffer size used by the sender:*



The effective window at the sender side controlling the transmission towards the receiver is given by:

EffectiveWindow = AdvertisedWindow – (LastByteSent - LastByteAcked)

(c) **(6p)**

N: Hvordan finner TCP (Transmission Control Protocol) den maksimale kapasiteten til nettverket slik at protokollen kan regulere pakkeraten den sender med inn i nettverket?

E: How does TCP (Transmission Control Protocol) find the maximum capacity of the network so the protocol can regulate its rate of transmitting packets into the network?

Segments transmitted into the network, a packet drop (or 3 duplicated ack) is interpreted as congestion. AIMD (Additive Increase Multiplicative Decrease) is used after slow-start to approach the maximum capacity. AIMD increases additively the congestion window. When the load exceeds the capacity the congestion window is multiplicatively decreased.

(d) **(6p)**

N: En måte å håndtere metning i nettverket er aktiv køhåndtering. Rutere langs en sti har kunnskap om fyllingsgraden til køene sine, og kan gi beskjed til ende-systemer om å redusere senderaten uten at pakker tapes. Beskriv hvordan en slik mekanisme kan implementeres i en lagdelt internettarkitektur.

E: An approach to network congestion management is active queue management. Routers along a path know their queue buffer occupancy, and may signal an end host to slow its sending rate without inducing packet loss. Describe how such a mechanism can be implemented in a layered internet architecture.

Explicit Congestion Notification (ECN) describes a way to signal congestion to sources before packet-dropping is required. IP packet from sender to receiver carries congestion encountered (CE) set by the routers. Receiver echoes this by a bit in the TCP header, ECE: ECN-echo flag. Sending TCP uses the CWR-flag (congestion window reduced flag) to stop the receiver from sending ECEs.

Oppgave/Exercise 5 Diverse/Miscellaneous

(a) **(6p)**

N: Registering av lokasjon (temporær adresse) er en funksjonalitet i de fleste mobilitetsprotokoller i nettverkslaget eller i et nettverk+ lag som er foreslått for Internett arkitekturen. Beskriv hvordan det blir gjort for Mobiler IPv4, Mobile IPv6 and HIP (Host Identity protocol).

E: Location registration (of current temporary address) is a functionality of mobility protocols at the network layer or at a network+ layer proposed in the Internet architecture. Describe how this is done in Mobile IPv4, Mobile IPv6 and in HIP (Host Identity Protocol).

In MIPv4 the location registration is done by the mobile node and the foreign agent at the home agent HA. The HA must be located in the same subnet as the original address of the mobile node.

In MIPv6 the mobile node registers the location at the HA and at the current communication partner.

In HIP the registration is done at a location server and to the partner of the current flow. In HIP there is a separate rendezvous point server (RP) that is used to find the address of a mobile host.

(b) **(4p)**

N: Hvilke tjenester kan et transportlag tilby?

E: What are the services a transport layer could offer?

Deal with out of order delivery Deliver messages in order of transmission Deliver one copy Support synchronization Implement flow control Support concurrent applications.

(c) **(4p)**

N: Stream Control Transmission Protocol (SCTP) er en forbindelsesorientert transportprotokoll som tilbyr tjenester som ikke finnes i TCP. Beskriv hvilken funksjonalitet i SCTP som kan benyttes for å tilby mobilitet i IP-nettverk.

E: Stream Control Transmission Protocol (SCTP) is a connection-oriented transport protocol that provides services unavailable in TCP. Describe which functionality of SCTP that can be used to offer mobility in IP networks.

***Multi-homing**: when a host with multiple points of attachment to the Internet, for redundancy purposes, does not want to wait for a routing convergence (often on the order of minutes) to communicate critical messages to its peer communication endpoint.*

***Multi-streaming**: several parallel streams between end points without head-of-line blocking*

As the mobile node moves around, new flows are set up within the same SCTP bundle - multi stream.

(d) **(6p)**

N: To konkurrenter kjøper PE-basert (provider edge) VPN (Virtual Private Network) ifra samme tjenesteleverandør. Den ene konkurrenten ønsker at forsinkelse på pakkene skal være mindre og prioriteten høyere for sin egen trafikk sammenliknet med konkurrentens. Diskuter om dette er teknisk mulig og hvis ja hvordan kan det implementeres.

E: Two competitors buy PE (provider edge) based VPN (Virtual Private Network) from the same service provider. One of the competitors would like to have a shorter packet delay and higher priority for its traffic compared to the competitor. Discuss whether this is feasible, and if so how it can be implemented?

In VPN there should be full isolation between the customers. (Each VPN should look as if have been implemented on separate circuits.) A single customer can request different priorities for its own traffic, but not relative to the rest of the traffic. The request is only feasible if the one competitor buys a better QoS-class than the other.