UNIVERSITY OF WISCONSIN-MADISON
Computer Sciences Department

Networking Depth Exam **Fall 2007**

Instructions: There are *six* questions on this exam; answer *ALL six* of the following questions.

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1. Internet Measurement

The Internet is a growing and evolving artifact that spans the globe. However, the lack of intrinsic measurement capability is a serious challenge to most efforts at understanding it's structure and behavior empirically.

A.

Describe the basic mechanisms for measuring and characterizing inter- and intra-network *structure/topology*. Describe at least two of the challenges in these approaches and how these might be overcome.

B.

Network service providers are usually quite reluctant to provide details on their own network's structure/topology. Is it possible to isolate and measure a single service provider's network? If so, how might this be done? If not, please explain why.

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2. Transport Control Protocol

TCP specifies how packets can be reliably exchanged between two end points. It also specifies how to react when congestion occurs along end to end paths, which is acknowledged as playing a critical role in the stability of the Internet.

A.

Describe how performance and stability are managed simultaneously in TCP and provide specific examples of incremental improvements that have been made to the basic Tahoe version of TCP in order to address observed shortcomings.

B.

The ability to predict TCP performance or to make future improvements in end-to-end performance is based on understanding the details of how the protocol behaves. Describe how TCP might be modeled, and which types of events can contribute to performance degradation.

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3. Wireless LAN Design

A common operational mode in traditional wireless LAN design, requires each client to associate with a single Access Point. In this design, each client is allowed to exchange packets only with the Access Point to which it associates. However, let us consider an alternate design where a client is able to associate with

multiple Access Points at the same time. In this new design a client is free to exchange traffic with more than one Access Point in transmission range.

A.

Describe two advantages of the alternate wireless LAN design described above.

B.

One possible way to implement such an alternate wireless LAN design without requiring any change to existing wireless clients is to, somehow, assign the same MAC address to all Access Points. Under these circumstances, when a client will not be able to distinguish between wireless packets sent by two different Access Points. Therefore, it will believe that it is actually communicating with a single Access Point, even though it exchanges packets with multiple different Access Points. The infrastructure, along with all Access Points, needs to implement additional logic for managing legacy clients to ensure that all existing applications in such clients operate without any loss in correctness or performance. Discuss at least two issues that the infrastructure and the Access Points need to implement to ensure smooth operations of existing higher layer protocols and applications at the legacy wireless clients under this new design.

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4. Mobility Support in the Internet

The Internet was originally designed under the assumption that all hosts in the network are statically located. As a consequence, the dominant TCP protocol uses IP addresses as names, and not as addresses. However, the reality today is that a dominant fraction of end devices are, in fact *mobile*. To support mobile devices, therefore, a number of patches have been introduced, one of which is the Mobile IP standard. Mobile IP uses a proxy (called a home agent) to forward traffic to and from the home network to the mobile client.

A.

While TCP can perform correctly when operating on top of Mobile IP, it pays some performance penalties when operating in this scenario. Explain one possible performance problem of TCP when operating on Mobile IP. Focus on the mobility related problems faced by TCP, ignoring issues that arise due to short-term variations in the wireless medium.

B.

Suggest a potential remedy to this problem faced by TCP, if you have the flexibility of re-designing mobility support in the Internet from scratch.

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5. Caching

In-network caching of documents can decrease network usage and load on the servers and it can reduce response time for clients. In the early days of the web extensive networks of caches were deployed inside the IP networks serving web clients. These in-network caches ran on dedicated high performance servers placed in strategically chosen locations within the network. Today in-network caching is performed not just by proxies operated by the organization connecting the clients to the Internet, but also by content distribution networks supported by content providers.

A.

Give at least three reasons why in-network caching is not as popular today as it was a decade ago. Give at least two reasons why a large web site would want to use a content distribution network.

B.

When a network of proxy caches is deployed, a cache can improve response time by contacting a nearby "sibling cache" that has the document requested by the client (instead of requesting it from the server). For this type of shortcut to be effective, the caches need to have a reasonably accurate and up to date image of what documents their "sibling caches" are storing. Explain how efficient data structures can be used to reduce the amount of network bandwidth required to exchange the lists of cached documents and to reduce the amount of memory required to store the summaries of documents stored by "sibling caches".

6. Inter-domain Routing

BGP is the de facto standard for wide area routing. While providing end-to-end reachability is the overriding goal of BGP, the BGP protocol does allow ISPs to encode policy decisions into their route selection procedure. For instance, using BGP's attributes, ISPs can define a variety of import rules which determine the specific routes that ISPs will prefer to reach particular destinations, and a variety of export rules which define which routes ISPs advertise to their neighbors.

A.

What are the most common import policies employed by today's ISP? What are the most common export policies employed by today's ISPs? The rules are largely governed by economic considerations of ISPs. Explain how ISP economic relationships (peering vs customer-provider relationships) determine which rules make most sense for ISPs to employ.

B.

Give an example of a simple annotated AS-level topology, where edges in the topology are labeled with the economic relationship between the neighboring ISPs, such that the ISP import/export rules from (a) above could cause the preferred route between a pair of ASes in the topology to be twice as long (in terms of the number of ASes) as the optimal AS-level route.

C.

If you were to redesign BGP from scratch, would you continue to have the protocol inherently support mechanisms for implementing economic policies as it does today? If yes, explain provide a justification of the benefits of doing this. If no, explain the downside of supporting policies within the protocol.