The Science of Cloud Computing – NSF PI Meeting

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Summary of Current Effort: Recently, we have been investigating the various economic issues associated with the design of a Cloud Service Discovery System, which acts as an intermediary and aids in the selection of relevant cloud-hosted software services for application developers. Specifically, we are investigating the pricing of these software services as they relate to various QoS metrics such as *Latency, Throughput, Privacy, and Security.* In particular, we are examining how the price correlated with the QoS provided by the service creators, i.e., whether there is significant heterogeneity in the QoS for a particular type of a service provided by the different developers and whether a lower price correlates positively with the lower QoS offered and a higher price with a higher QoS. The interesting question here is whether service creators would differentiate themselves on the basis of price and QoS when all the creators have equal access to the underlying Cloud Computing infrastructure and thus, are capable of providing the same QoS to consumers at exactly the same cost.

Future Research Plans if Funded

Based on our current work, the issues that we plan to investigate are related to the following topics (from the list mentioned in the CFP): *2. Network Support for the Cloud*, and *6. Cloud Security, Privacy, and Auditing*. These are briefly discussed below.

Network Support for the Cloud

One of the principle attraction of Cloud Computing (CC) is that it allows a great deal of flexibility for Internet commerce. The advantages of Cloud Computing for Internet commerce are: i) The ability to store large amounts of information that can be accessed at all times; ii) The ability to allow multiple networks to link via CC; iii) Because of economies of scales, it lowers the costs to firms of providing information services to its customers; iv) Allows consumers to search and gather information about prices and attributes of different services at very little cost; v) In many cases, the mode of delivery itself undergoes substantial changes as in the case of movie rentals - Netflix delivers rental movies directly through its Web site requiring high levels of network support.

Questions to be investigated: i) Does CC increase welfare and total trade?; ii) Does CC lower the entry costs and increase competition?; iii) How much network support to provide for CC-based system and who should bear the associated cost?; iv) Is there a case for public support for networks for the Cloud?

Cloud Security, Privacy and Auditing

Privacy and security are two important QoS issues that arise in CC specifically because of its open access nature. Both have two interrelated but separate aspects - one is purely technological and involves the development of software and hardware that increases both privacy and security, the other is the adoption of sometimes costly technologies for providing both privacy and security. In some cases, privacy and security is absolutely essential and the business cannot function without adequate levels of these-this is true, for instance, for credit card companies and banks.

Questions to be investigated: i) One of the trade-offs that can be made in this case is to provide less access but charge lower fees. For instance, a bank or a credit union will need to decide whether it is worthwhile to provide access at all times or to limit access to certain times of the day. What are the factors that affect such a trade-off?; ii) To what extent do firms invest in providing high levels of security and privacy? – Firms will usually balance the need to maintain its reputation and the cost it is willing to incur for privacy and security. iii) In some cases, guaranteeing a promised level of security requires continuous monitoring of the cloud-hosted service. An optimal monitoring strategy can be obtained by examining the strategies in a *game of attrition* between the provider and the adversaries. This might suggest optimal methods of monitoring that could provide higher levels of security at lower cost. How can this game be formalized?