Masters Thesis: Age of Information

Background

Age of Information (AoI) is a recently proposed metric that quantifies the *freshness* of a data packet in a network [1]. Since the inception of networking and communication systems, *delay* of a data packet has been the primary Quality of Service (QoS) requirement. However, freshness of the data or the AoI metric is gaining more and more attention as these systems evolve into networked-control systems that support emerging time-critical applications such as autonomous vehicle systems, automation of manufacturing processes, smart-grid system etc. In contrast to human-related data applications (e.g. smartphone apps), the freshness of the status updates/packets is critical for optimal control in these networked systems.

The AoI metric, denoted by $\Delta(t)$, is defined as the time elapsed since the generation of the latest status update received at the destination. Formally, $\Delta(t) = t - U(t)$, where $U(t)$ is the generation time of the most recently generated packet that is received at the destination. In Figure 1, we show an example evolution of the AoI process. To put his in the context of a real system, consider the system shown in Figure 2. A source (e.g. a sensor) samples a process of interest and submits the status update to a server which transmits them in first-come-first-serve fashion. Whenever a status update is received at the destination (e.g. monitor/estimator of the process), the age of the status update is equal to its waiting time in the queue plus its transmission time. In contrast to *delay* which increases with sampling rate R, AoI has the property that it increases at both high and low sampling rates [2]. This property led to several research works for computing sampling rate that minimizes AoI. However, all these works focused on minimizing "average" AoI. In our recent work [3], we have studied the optimization of sampling rate with the objective of tail distribution of AoI for time-critical applications. However, there are several timely and important research questions that needs to be addressed.

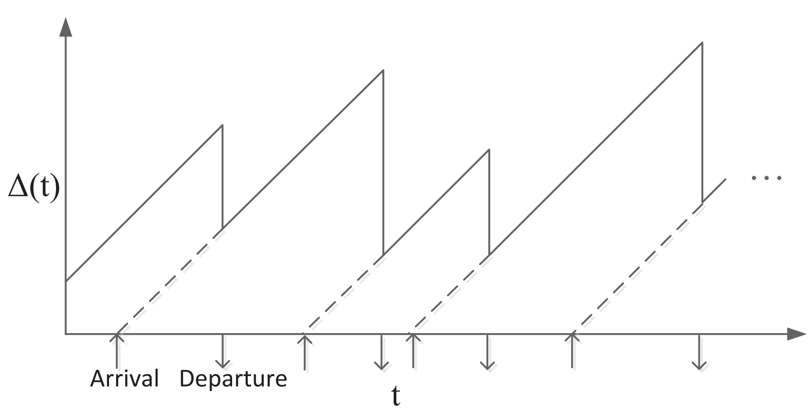

Fig. 1. A sample path of AoI process $\Delta(t)$.

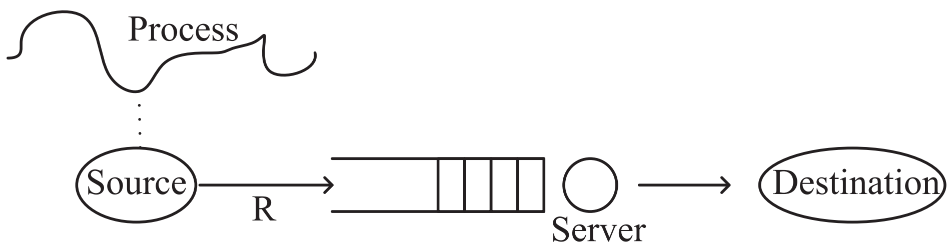

Fig. 2. Status updates from a source (e.g. sensor) are communicated to a destination (e.g. controller/monitor)

Task: Understand the AoI metric and the related research works. The student may extend the research problem studied in [3]. For example, one may extend the system model in Figure 2 and consider multiple processes are being observed, or study the problem for a multi-hop system, or consider other queueing policies such as last-come-last-serve. The student is also strongly encouraged to pursue his/her own problem statement related to AoI. Solve the problem either numerically or analytically with theoretical proofs.

Requirements: The student must have background in probability and random processes and is strongly motivated/interested in proving theoretical results. Be able to do simulations using MATLAB/C or other programming languages. A course in queueing theory would be an added advantage.

Contact

If you are interested in more details about the project please email to Jaya Prakash Champati at jpra@kth.se

References

[1] S. Kaul, M. Gruteser, V. Rai, and J. Kenney, "Minimizing age of information in vehicular networks," in *Proc. IEEE SECON*, 2011.

[2] S. Kaul, R. Yates, and M. Gruteser, "Real-time status: How often should one update?" in *Proc. IEEE INFOCOM*, 2012.

[3] J. P. Champati, H. Al-Zubaidy, and J. Gross, "Statistical guarantee optimization for age of information for the d/g/1 queue," in *Proc. IEEE INFOCOM AoI Workshop*, April 2018, pp. 130–135.