Age of Information

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Age of Information: WHY?

- The timeliness of status updates in modern cyber physical systems has emerged as a novel promising field of network research

TIMELY UPDATING ≠ SYSTEM UTILIZATION MAXIMIZATION ≠ DELAY MINIMIZATION

Age of Information: WHY?

System utilization maximization: we need to send updates as fast as possible

May produce delayed packets backlogged in the communication system

New Metric:
The Age of Information

Timeliness updating can be achieved reducing the update rate

But may produce lack of updates, having outdated information

AoI as Performance Metric

The Age of Information (AoI) is an end-to-end metric used to characterize latency in status updating systems. It measures the timeliness updates at a remote monitor.

u timestamp of a packet

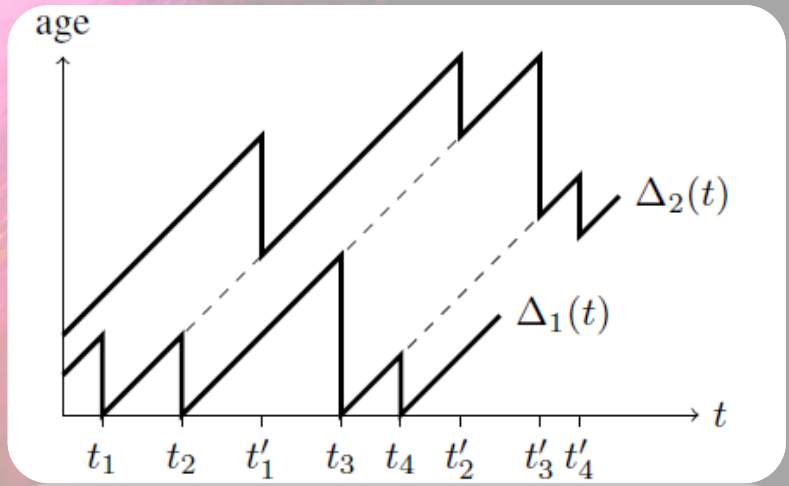
$t - u$ age of the packet

$u(t)$ timestamp of the freshest packet received at the monitor

AoI $\Delta(t) = t - u(t)$

AoI as Performance Metric

Fresh updates from a source pass through the network to a destination monitor. Monitor 1 (marked by ✸) sees fresh update packets at the network access link. Since Monitor 1 sees fresh updates as a point process at times t_i, its age process $\Delta_1(t)$ is reset to zero at times t_j. Since the destination monitor sees updates that are delivered at times t_j' after traveling through the network, its age process $\Delta_2(t)$ is reset to $\Delta_1(t_i') = t_j' - t_j$, which is the age of update j when it is delivered.



Yates, R., Sun, Y., Brown, D.R., Kaul, S.K., Modiano, E., & Ulukus, S. (2020). Age of Information: An Introduction and Survey. ArXiv, abs/2007.08564.

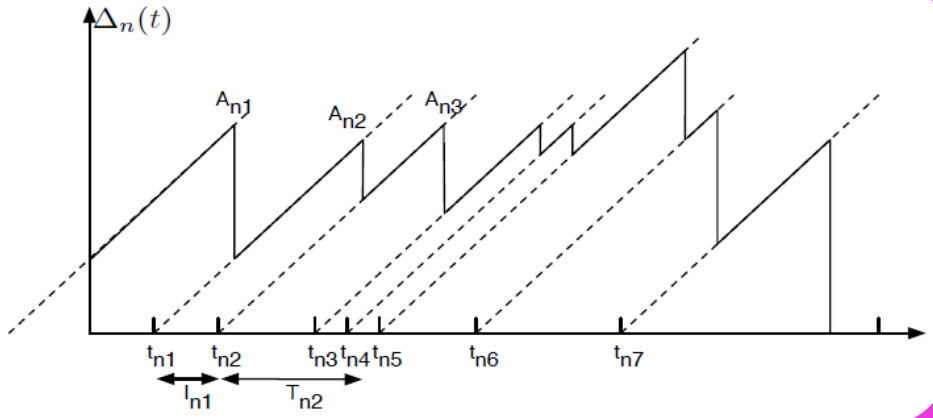
AoI Metrics

Time Average AoI

$$A = \lim_{T\to\infty} \frac{1}{T} \int_{t=0}^{T} \Delta_n(t)dt$$

Peak AoI

$$B = \lim_{K\to\infty} \frac{1}{K} \sum_{k=1}^{K} A_{nk}$$

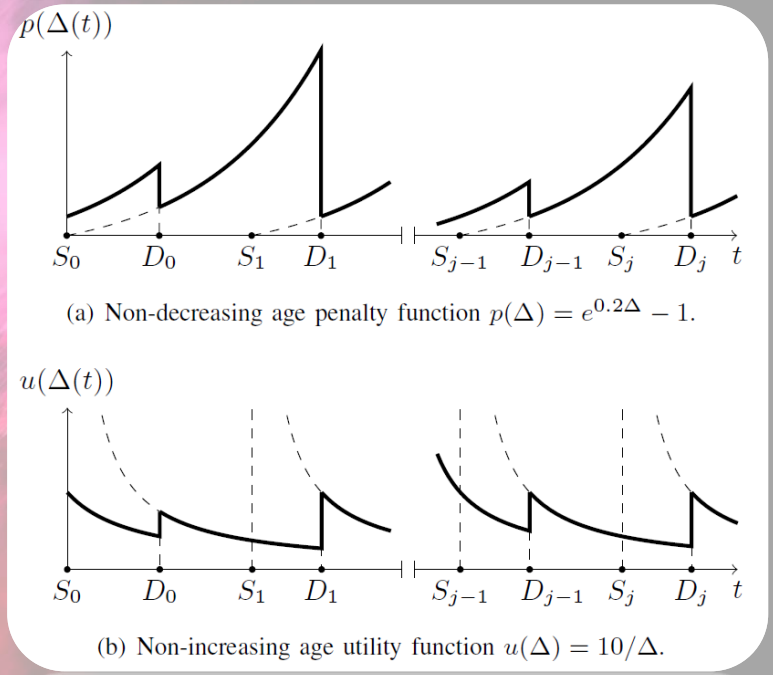


Huang, L., & Modiano, E. (2015). Optimizing age-of-information in a multi-class queueing system. 2015 IEEE International Symposium on Information Theory (ISIT), 1681-1685.

AoI Metrics

One approach for characterizing the nonlinear behavior of information aging is to define freshness and staleness as nonlinear functions of the AoI. Dissatisfaction with information staleness can be generally expressed with a non-decreasing function and allows also non-convex or discontinous expressions.

Similarly, information freshness can be characterized by a non-increasing utility function.



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THANK YOU!

We are impatient to work with you. We always welcome applications from visiting scholars at all levels (students, faculty, postdocs) who are interested to spend some time in our lab and get involved in our ongoing research activities.