On Implementing Time

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Motivation

- functionality and security of apps hinges on some notion of time.
- choose from multiple time values on systems.
- applications oblivious to implications of choosing one or the other time value for implementation
This draft

- describes properties of various time values available on modern operating systems
- discusses trade-offs of using one over the other
- provides guidance to help implementers make an informed choice
Outline

• define available clocks
• how they are different?
• expressing time: time stamps vs time spans
• current implementation & why is it bad?
• alternative approaches
Different clocks

- **Wall time**: agreed upon “ideal time”
- **Raw time**: unadjusted system time
- **Adjusted raw time**: raw time fixed for clock drift
- **Real time**: adjusted raw time shifted to match wall time
# Differences from wall time

<table>
<thead>
<tr>
<th>raw time</th>
<th>adjusted raw time</th>
<th>real time</th>
</tr>
</thead>
<tbody>
<tr>
<td>difference in time b/w two points</td>
<td>absolute time value</td>
<td>can jump in either direction</td>
</tr>
<tr>
<td>monotonically increasing</td>
<td>adjustable (manually/network time protocols)</td>
<td></td>
</tr>
<tr>
<td>not adjusted for clock drifts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Raw time** is not adjusted for clock drifts.
- **Adjusted raw time** is adjustable (manually/network time protocols).
- **Real time** can jump in either direction and has an absolute time value.
Expressing time

time spans vs time stamps

• **Time spans**: represent desired length of time
e.g. time-out values or time-to-live (TTL) values

• **Time stamps**: represent a point in wall time
e.g. validity of objects from and to a fixed time
How do software implementations deal with time stamps & time spans?

**COMMON APPROACH**

Time spans - translated to time stamps.

Time stamp = current system time

Updated by NTP
Why is it bad?

- Real Time
  - can be set or overwritten manually
  - subject to adjustments by timing protocols
    - Recent attacks [1,2,3] show off-path time-shifting and Denial-of-Service attacks on these protocols

Note: Time stamps always based on wall time
Alternative implementation approaches for time spans

• SHOULD NOT use real time

• Other options?
  - raw time
  - adjusted raw time

• Application specific: tolerate clock drift to a certain amount can use raw time, otherwise adjusted raw time
Way forward for the draft?

References:

