Lecture 15 - Google's F1 Database

Google F1 - https://youtu.be/94_mv19gHxs
Byzantine Generals - https://youtu.be/EioBX3K7Frw
Google F1 pt2 - https://youtu.be/CCyyFJRDFrU
Walk through of Front End - https://youtu.be/CCyyFJRDFrU

From Amazon S3 - for download (same as youtube videos)

Google F1
Byzantine Generals
Google F1 pt2
Walk through of Front End

Before we start on F1

Some more code to go through in the front end for Assignment 04.

What is Distributed Consensus

Byzantine Generals Problem

This was originally described by L. Lamport [4] in 1982. It is the underlying problem and solution that is behind blockchain and cryptocurrency.

Basically you have multiple independent systems sending messages. Some of the systems can like. You want to get to a consensus where a set of data is agreed upon. This was originally developed for systems that control airplanes and is still heavily used in flight-controls. Real time systems like cars, planes and others use this today.

Lamport's "discovery" was that you can not assume that a system is honest. Systems can lie. They can receive accurate data and then send inaccurate data to others. They don't just fail and stay kited. They can fail and produce garbage data.

The real question is how do you assure that multiple systems or people that are at different locations agree on a "world state" before taking some action.

This is based on the Paper "Practical Byzantine Fault Tolerance" by Castro [5] in 1999:

1. Commander sends the value to every lieutenant
2. Every lieutenant
   - if it receives a new value v, broadcast (prepare, v)
   - if it receives 2f+1 (prepare, v), broadcast (commit, v)
   - if it receives 2f+1 (commit, v), broadcast (committed, v)
   - if it receivers f+1 (committed, v), broadcast (committed, v)
3. Ensure agreement
4. Ensure liveness under an loyal commander

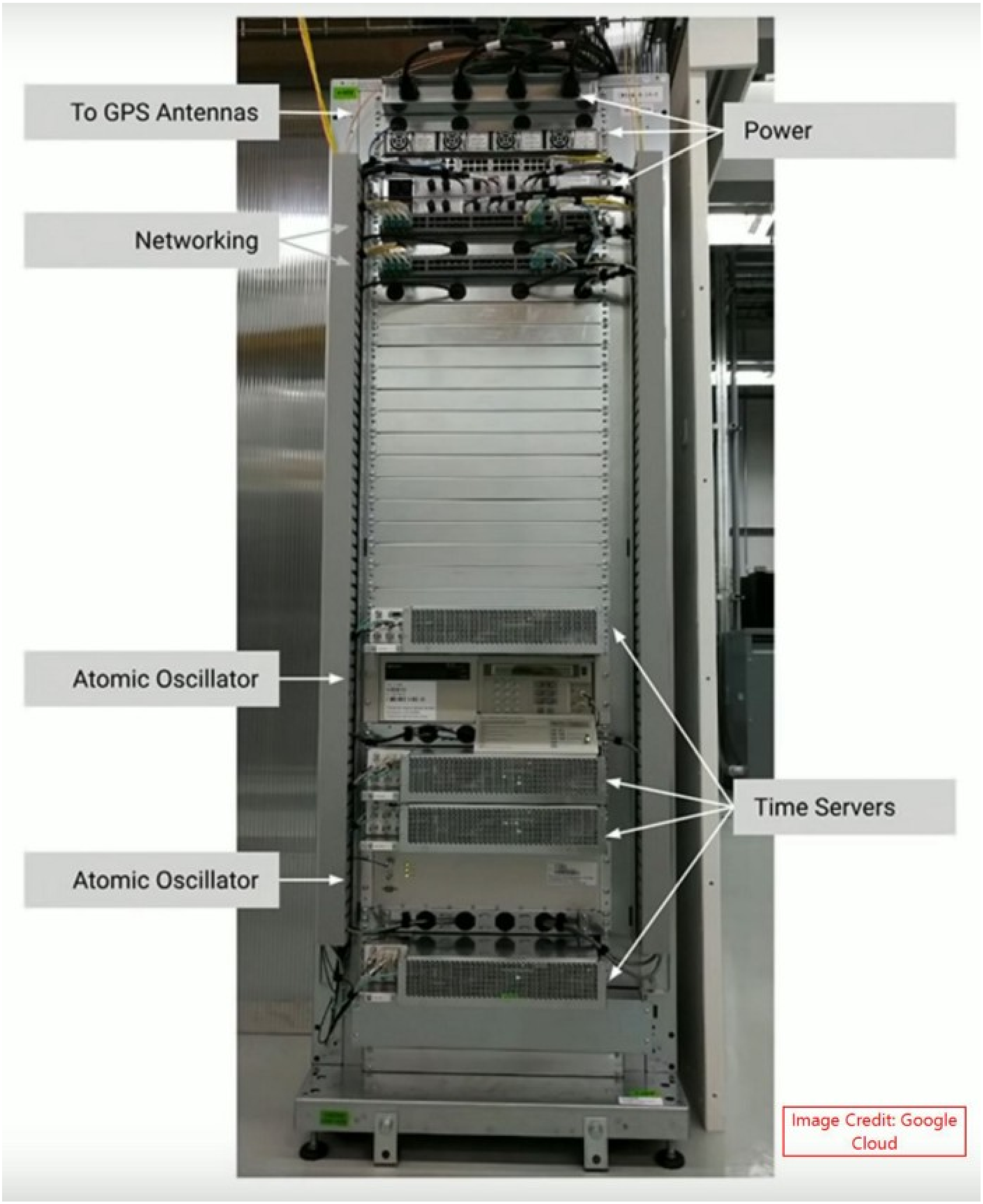
Clock solution to Distributed Consensus

This is L. Lamport's other contribution to distributed fault tollerance. A provable consensus system using accurate clocks. I think his paper on this was in 1978.

The commercial version of F1 [1] is "spanner" the worlds first global scale database. You can use it by using Google Compute Cloud database. It is the database under gmail, Google docs, and doubleclick - the advertising platform. This means that all of use it many times a day. 74% of the web has google analytics on it - feeding data - billions of rows a day into it.

At the hart of this is the Google TrueTime [2] API - you can use it also. True time is a microsecond accurate time clock in the API that is globally accurate. By globally I mean that the data center in Dublin Ireland will give you the same results as Portland Oregon. To do this Google used atomic clocks in its data centers and adjusted for the curvature of space time (General Relativity). It then went to substantial effort to get all of the clocks to agree.

This is only the 2nd application of Einstein's General Relativity in the world. GPS is the 1st.



When you change data a “leader” is picked. This is the system that will make the change. This is done if the changes is within a single block. The leader changes the block then distributes the block to all the systems that have a replica of the block.

The leader is picked based on who responds the fastest (Remember the clocks).

If the change spans more than 1 block then a coordinator for a 2-phase commit is picked in the same way. The coordinator manages the 2-phase over the set of single block commits.

In all cases the process chooses reliability over speed.

References

1. Google's F1 Database Paper: https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/41344.pdf
2. Google Spanner Database: https://levelup.gitconnected.com/how-google-spanner-assigns-commit-timestamps-the-secret-sauce-of-its-strong-consistency-8bc143614f26
3. TrueTime System: https://medium.com/searce/internals-of-google-cloud-spanner-5927e4b83b36
4. Byzantine Fault Tollerance: https://people.eecs.berkeley.edu/~luca/cs174/byzantine.pdf
5. Practical Byzantine Fault Tollerance: http://pmg.csail.mit.edu/papers/osdi99.pdf