

FRED HEBERT

A BRIEF HISTORY OF TIME



**“I WOULD DIE IN THE
WILD”**

- myself



TIME ACCOUNTING

OBSERVE.



EGYPT

A SOLAR CALENDAR



ETHIOPIAN, COPTIC



GREEKS LIKED THE MOON MAYBE

LUNAR CALENDARS



B

ISLAMIC



BABYLONIANS GET FANCY

A LUNISOLAR CALENDAR



ICELANDIC



COMMITTED TO BACKWARDS
COMPATIBILITY

HEBREW CALENDAR

[THE NEW YEAR] COINCIDES WITH THE CALCULATED DAY OF THE MEAN CONJUNCTION OF TISHRI [7TH MONTH] — 12 MONTHS AFTER THE PREVIOUS NEW YEAR IN ORDINARY YEARS, AND 13 IN LEAP YEARS—UNLESS ONE OF 4 DELAYS IS MANDATED:

Calendrical Calculations, Dershowitz & Reingold, 2008

1. IF THE TIME OF MEAN CONJUNCTION IS AT MIDDAY OR AFTER, THEN THE NEW YEAR IS DELAYED
2. IN NO EVENT MAY THE NEW YEAR BE ON SUNDAY, WEDNESDAY, OR FRIDAY [... OTHERWISE] THIS RULE COMBINES WITH THE PREVIOUS RULES AND RESULTS IN A 2-DAY DELAY

Calendrical Calculations, Dershowitz & Reingold, 2008

3. IN SOME CASES (ABOUT ONCE IN 30 YEARS) [...] IF ROSH HA-SHANAH [NEW YEAR] WERE BEFORE NOON ON TUESDAY OF A COMMON YEAR AND THE CONJUNCTION OF THE FOLLOWING YEAR AT MIDDAY OR LATER, THEN APPLYING THE PREVIOUS TWO RULES WOULD [...] REQUIRE AN UNACCEPTABLE YEAR LENGTH OF 354 DAYS, AND THUS THE CURRENT ROSH HA-SHANAH IS DELAYED UNTIL THURSDAY [...]

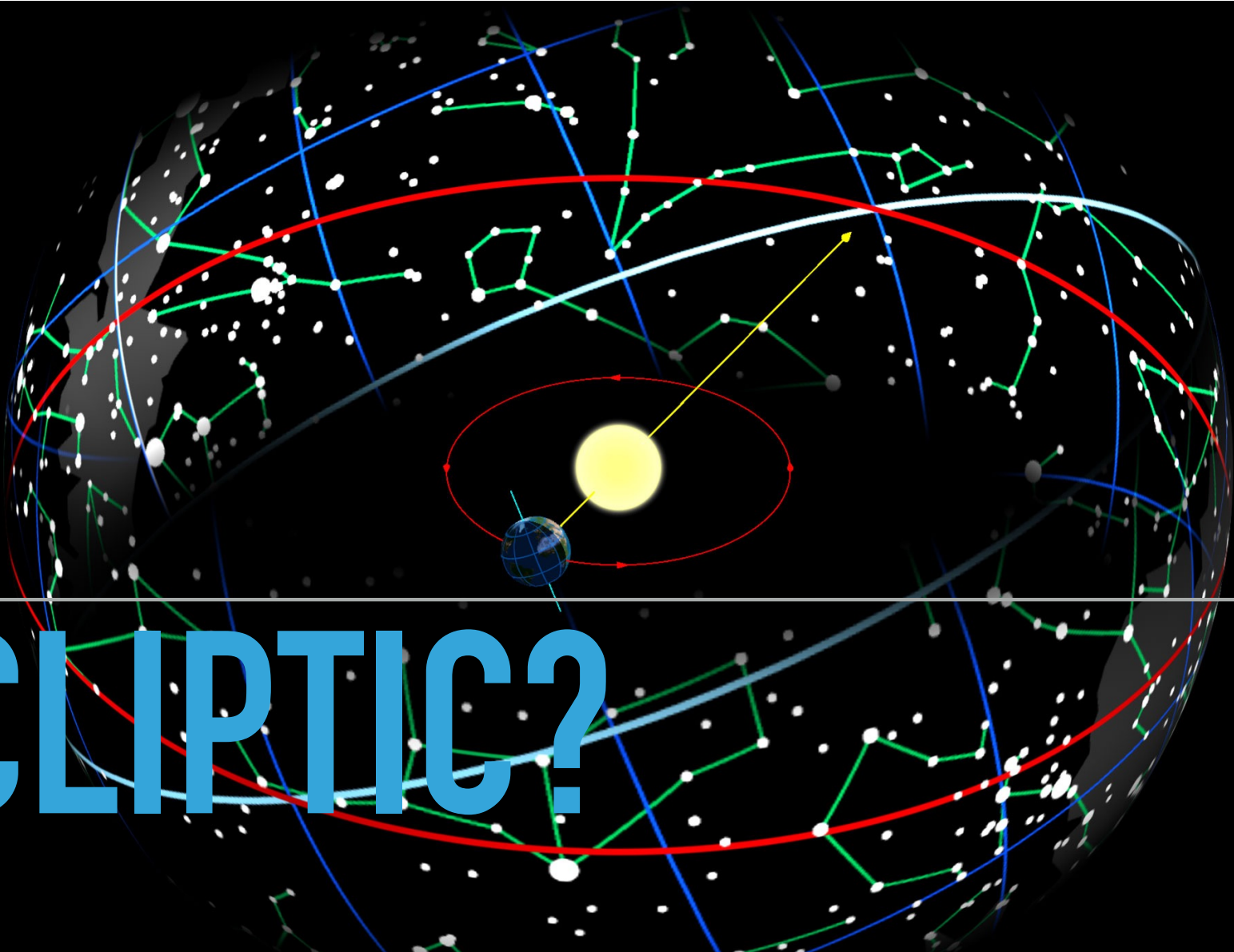
Calendrical Calculations, Dershowitz & Reingold, 2008

4. IN RARE CASES (ABOUT ONCE IN 186 YEARS), ROSH HA-SHANAH IN MONDAY AFTER A LEAP YEAR CAN POSE A SIMILAR PROBLEM BY CAUSING THE YEAR JUST ENDING TO BE TOO SHORT—WHEN THE PRIOR NEW YEAR CONJUNCTION WAS ON MIDDAY ON TUESDAY AND WAS, THEREFORE, DELAYED UNTIL THURSDAY. IF THE CONJUNCTION WERE AFTER MIDDAY TUESDAY THE PREVIOUS YEAR THEN IN THE CURRENT YEAR IT WOULD BE AFTER 9:32:43^{1/3} A.M. ON MONDAY. IN THIS CASE ROSH HA-SHANAH IS POSTPONED FROM MONDAY TO TUESDAY, EXTENDING THE LEAP YEAR JUST ENDING FROM 382 DAYS TO 383. THE CURRENT YEAR CANNOT BECOME TOO SHORT BECAUSE OF THIS DELAY. IT IS SHORTENED FROM 355 DAYS TO 354, WITH THE FOLLOWING ROSH HA-SHANAH BEING DELAYED UNTIL SATURDAY.



BACKWARDS INCOMPATIBLE

ROMAN, JULIAN, GREGORIAN



ECLIPTIC?



OVER 50 EDITIONS

CHINESE

OTHER INTERESTING CALENDARS

- ▶ Mayan: uses day counting and multiple nested cycles. 365-day year.
- ▶ Persian: similar to Ethiopian calendar, but based on astronomical events rather than just arithmetic. Week starts on Saturday.
- ▶ Baha'i: astronomical, uses 19 months of 19 days (+4-5 trailing days) and starts on vernal equinox. Days start at sundown. Leap days added like Gregorian. Counts cycles of 19 years.
- ▶ French revolutionary: used from 1793 to 1806. Astronomical, 12 months of 30 days (+ 5-6 trailing days). 3 weeks of 10 days per month



**“SECONDS SINCE
JANUARY 1ST 1970
SHOULD BE GOOD
ENOUGH”**

- Computer Programmers, probably.

UGHT TO BE ENOUGH, RIGHT.

WHAT COULD GO WRONG?

- ▶ Year 2000, anyone? What about 2038? Or 2036 for NTP? 2042 for IBM mainframes?
- ▶ Microsoft Excel has since its earliest versions, incorrectly considered 1900 to be a leap year; inherited from Lotus and kept for backwards compat. Now a requirement in the Ecma Office Open XML (OOXML) specification
- ▶ Almost delayed shuttle launch in 2007 to avoid going in orbit over new year
- ▶ Setting the date to Jan 1st 1970 will brick your iPhone
- ▶ Linux Kernel in 2012 would livelock during a leap second and crash plenty of services

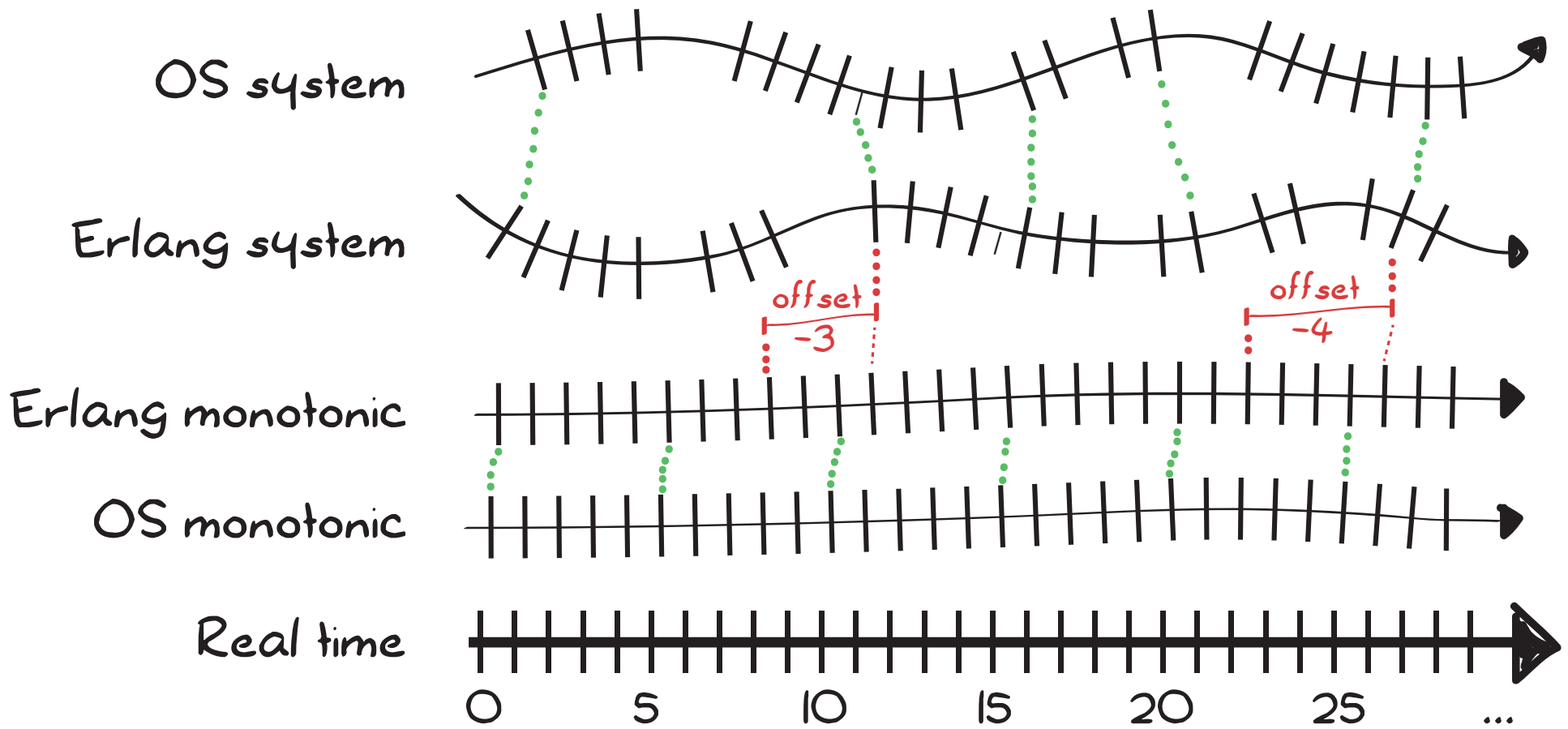
OH SO MANY MORE THINGS

- ▶ Taiwan uses the Minguo calendar, which considers the Gregorian year 1912 to be year 1. Thus, the Gregorian year 2011 is their year 100, had issues similar to Y2K (called Y1C)
- ▶ Google Calendar and settings meetings far in the future is weird
- ▶ iOS bug where non-repeating alarms wouldn't work on first few days of year
- ▶ The Deep Impact Spacecraft lost communication with Earth in August 2013, after a clock counted 2^{32} tenth-seconds after January 1st, 2000.
- ▶ Confused students try to by boose every year without actually being of drinking age

A close-up photograph of a single fried egg in a dark, non-stick pan. The egg is sunny-side up, with a bright yellow yolk and a white, slightly bubbled egg white. The background is dark, making the egg stand out. Overlaid on the bottom left of the image is the text 'THIS IS YOUR BRAIN ON' in white, followed by a horizontal line, and then the word 'TIMESTAMPS' in large, bold, blue letters.

THIS IS YOUR BRAIN ON

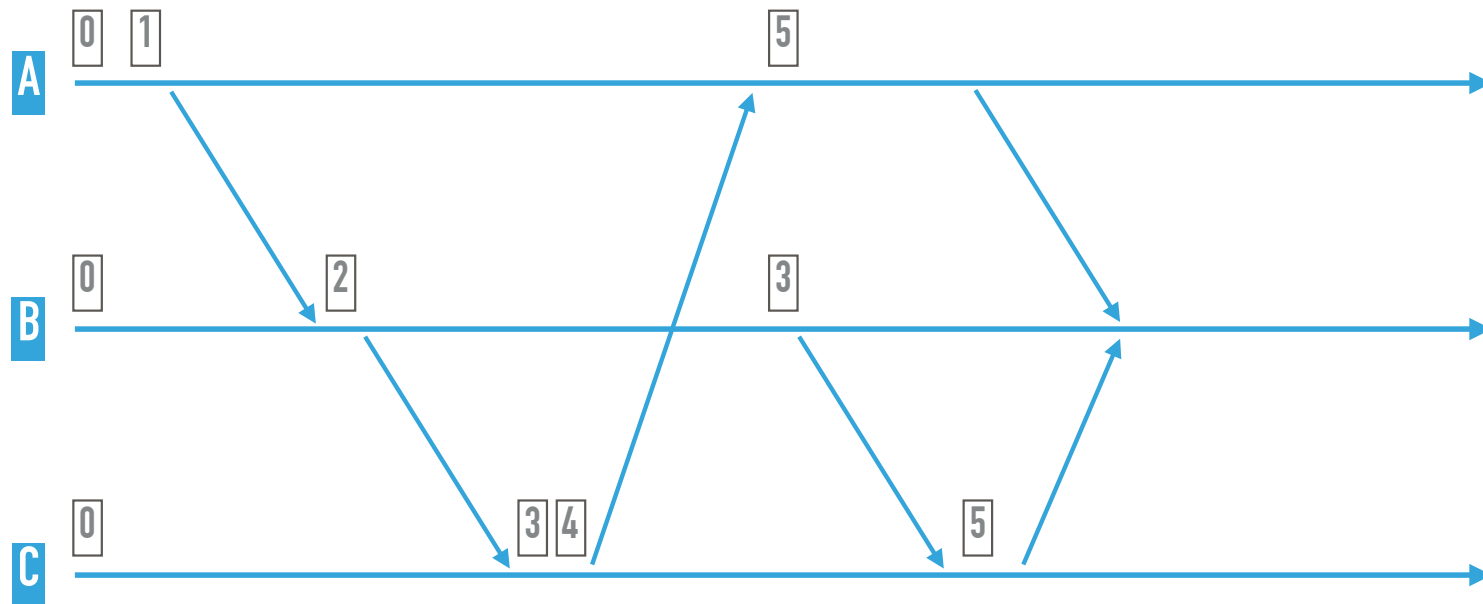
TIMESTAMPS



IN A DISTRIBUTED SYSTEM, IT IS IMPORTANT TO REALIZE THAT THE ORDER IN WHICH EVENTS OCCUR IS ONLY A PARTIAL ORDERING.

Leslie Lamport

LAMPORT CLOCKS

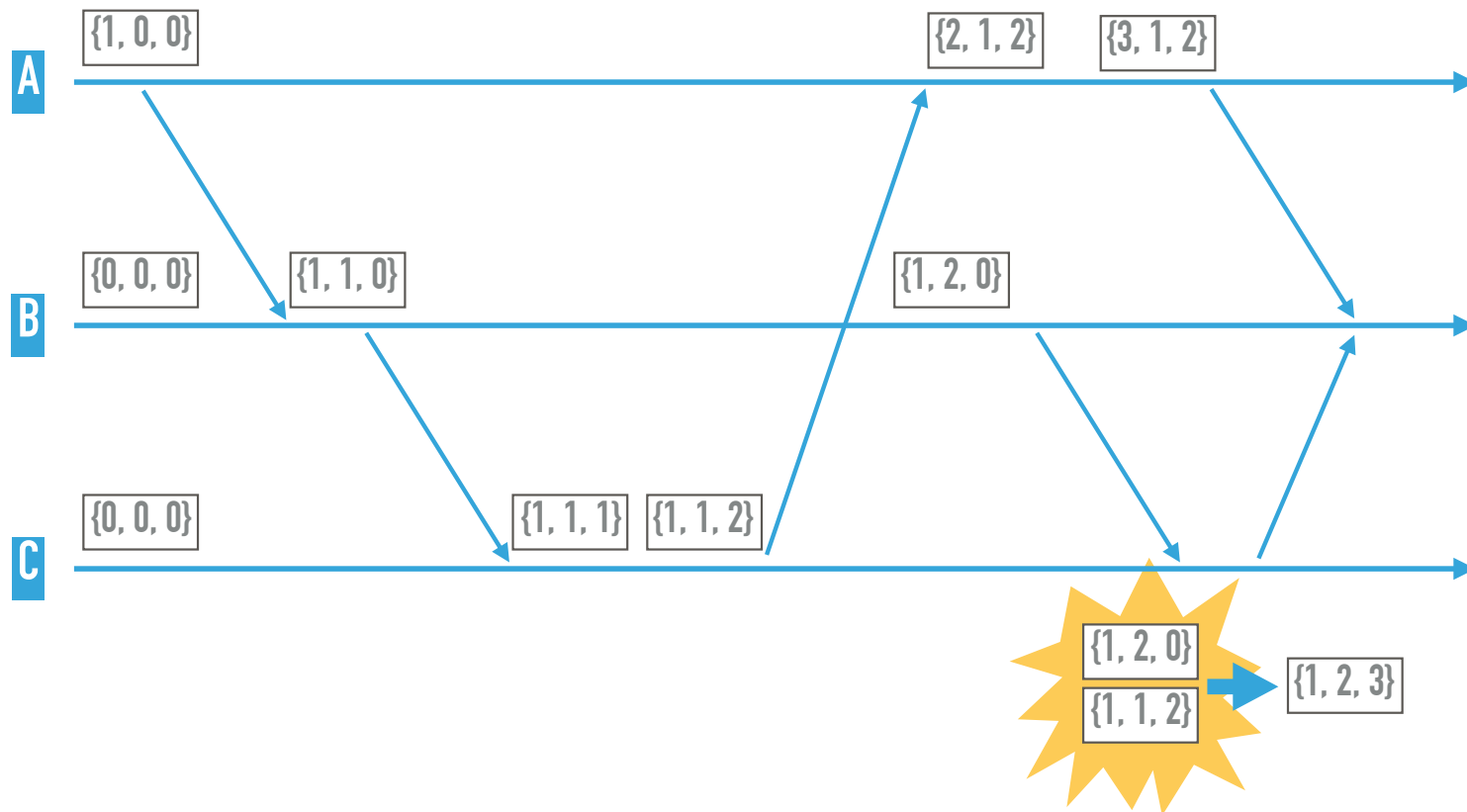


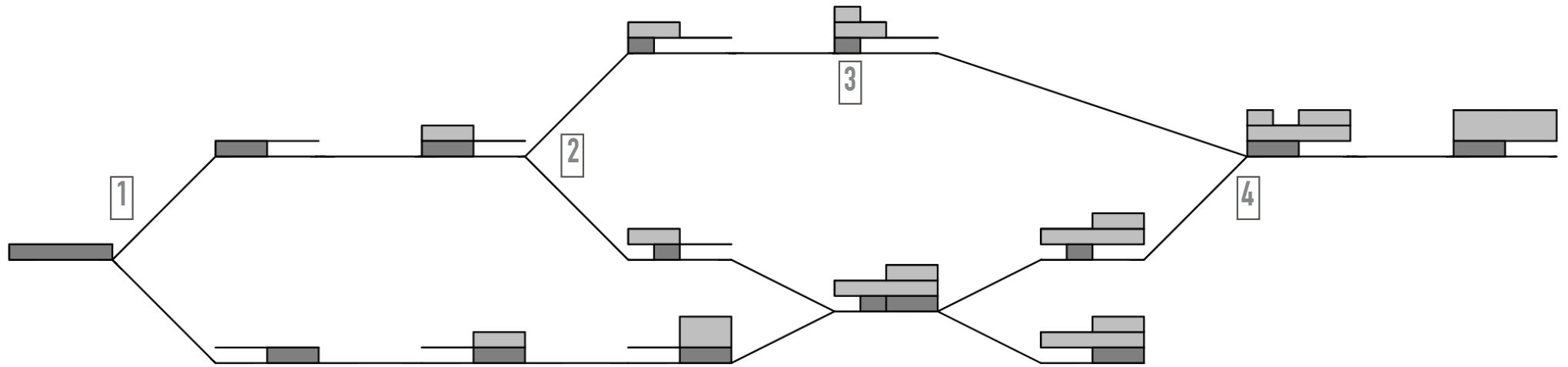


LAMPORT AND NTP HAD A
BABY

**HYBRID LOGICAL
CLOCKS**

VECTOR CLOCKS

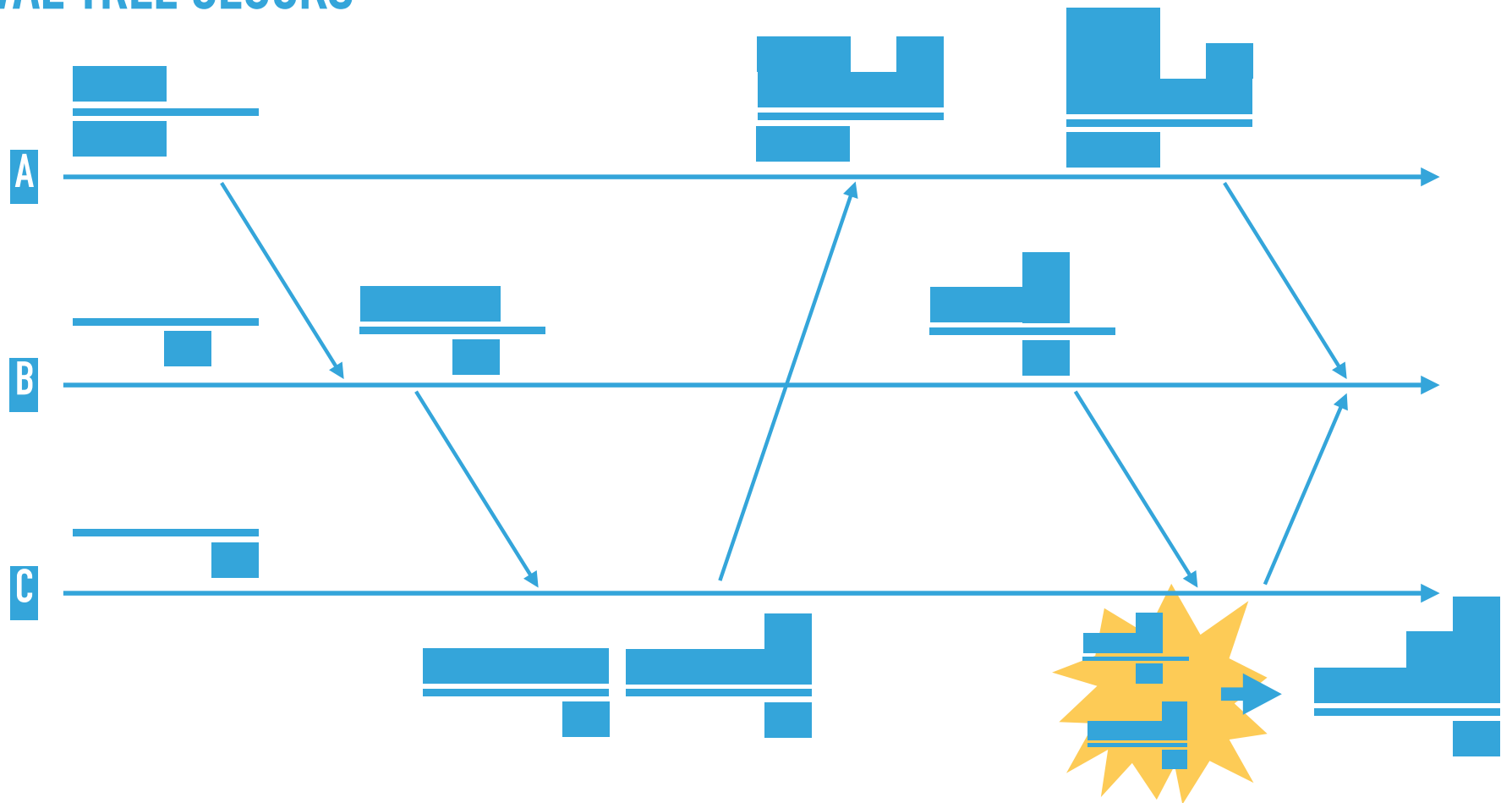




THE COOLEST PAPER

INTERVAL TREE CLOCKS

INTERVAL TREE CLOCKS





SCREW TIME

CRDTs



INFERNAL MACHINE

ARE YOU AFRAID YET?

QUESTIONS?