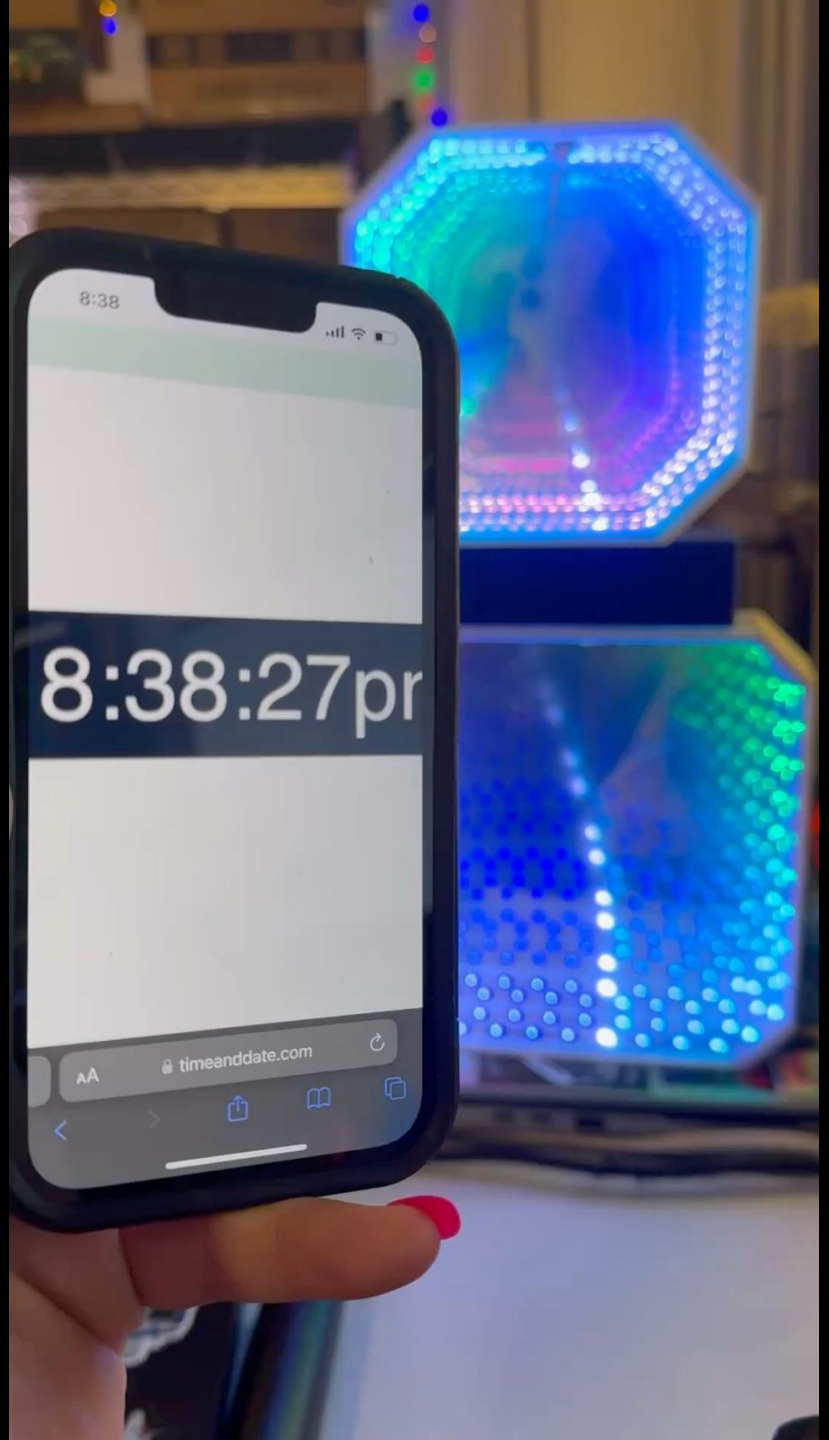
Bye Bye Bye, Clock Sync

An exploration of synchronizing blinky lights

Amelia Wietting

AKA Aask Questions



Hey, I’m Amelia

Aask Questions

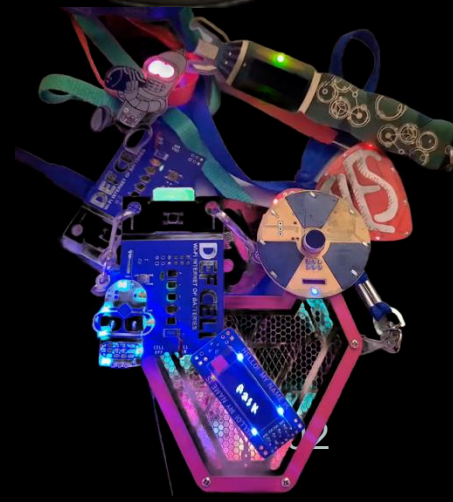
Hacker. Maker. Breaker.



“I roll my face on the keyboard and vulns fall out.”

True story.
I also hack tractors!
CyberTractorChallenge.org

Website: https://aask.ltd
Email: me@aask.ltd



The origin story

>be me

>embedded security researcher

>sees windmills blinking in BFE, wants it at DEF CON

>it’s basically jeff's mom's basement. no wifi. no gps.

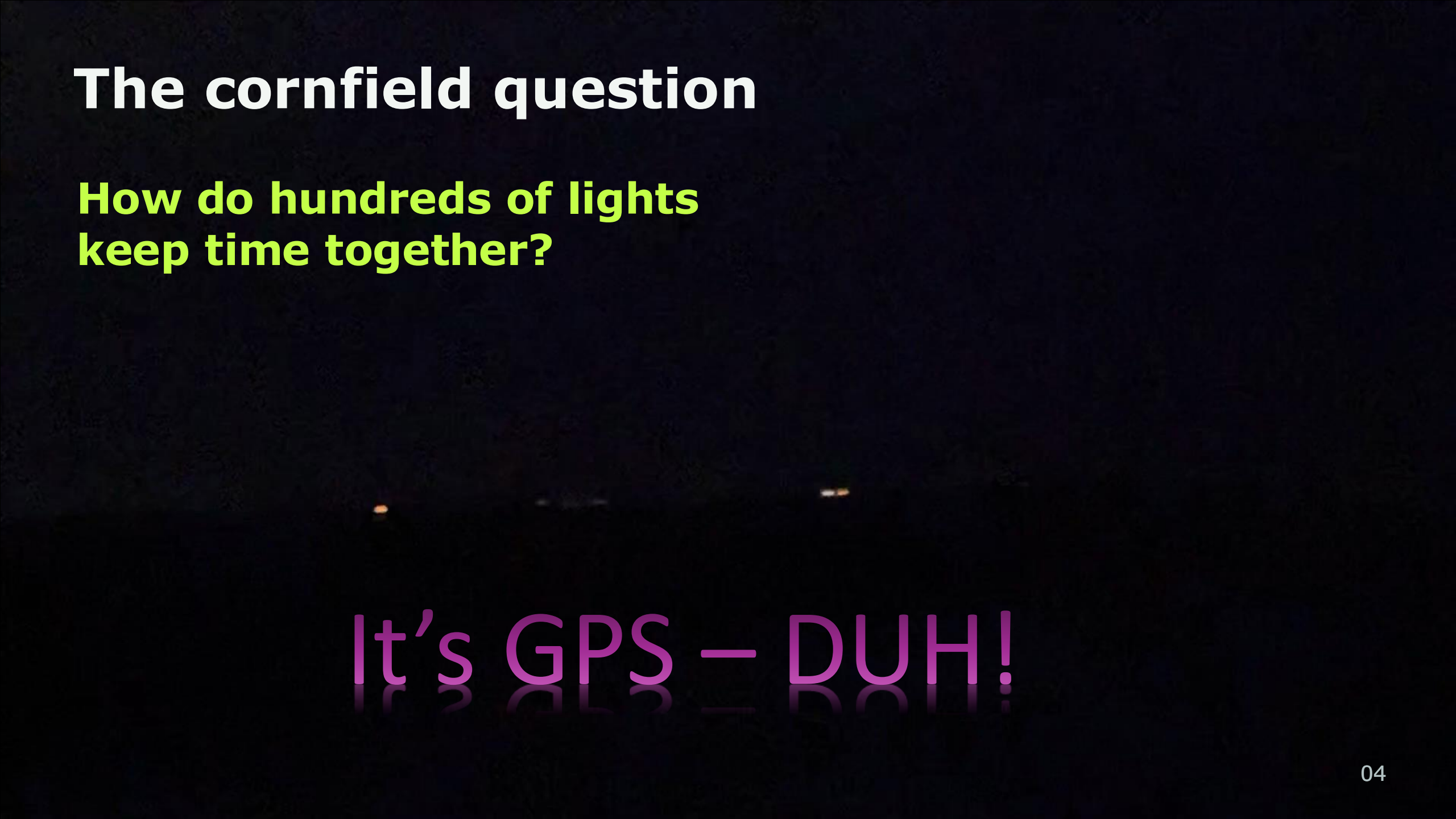
>watching NSYNC reunion clips at 3am

>realize they haven't been in sync since 2002

>neither have my fucking clocks

The cornfield question

How do hundreds of lights keep time together?



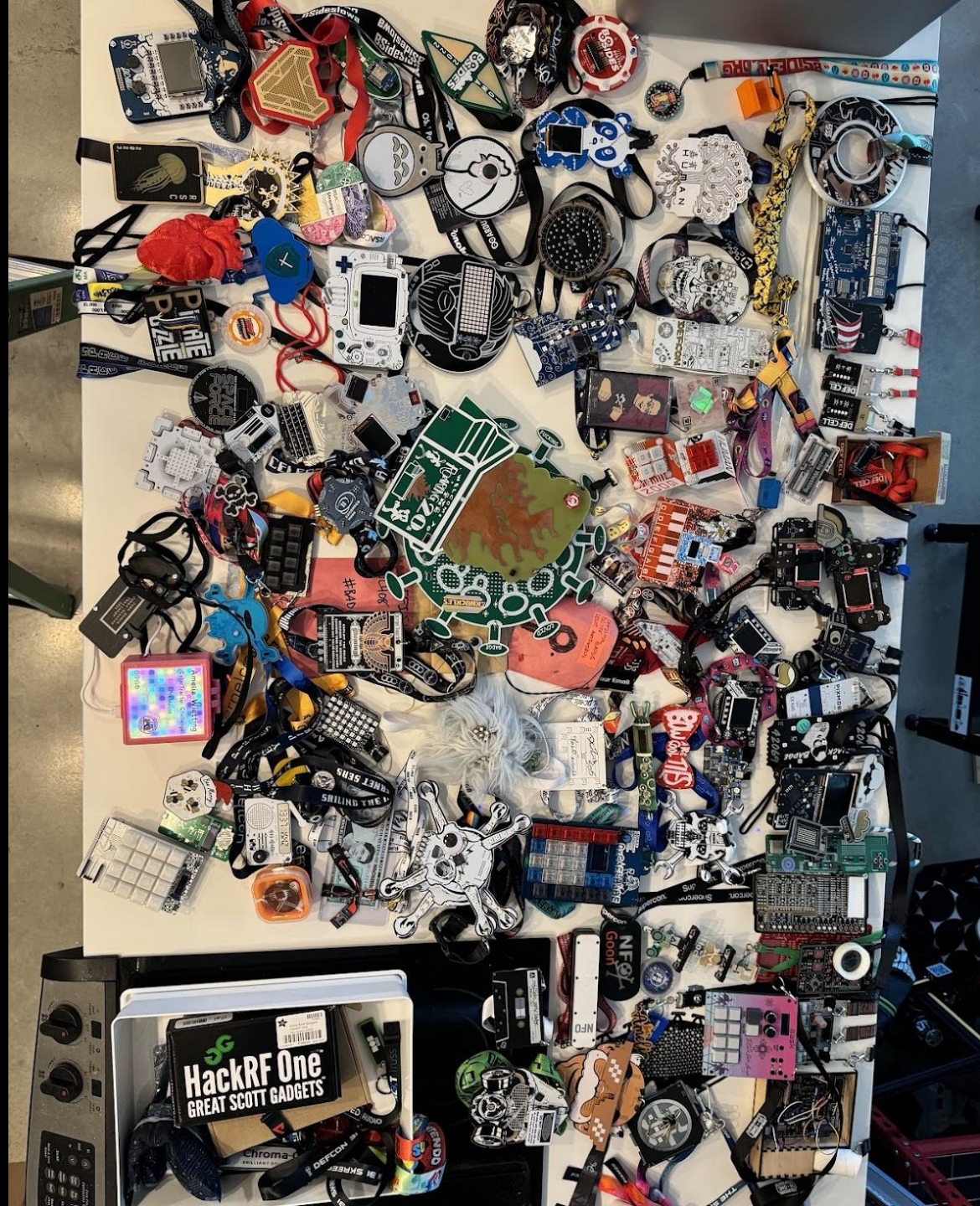
It’s GPS – DUH!

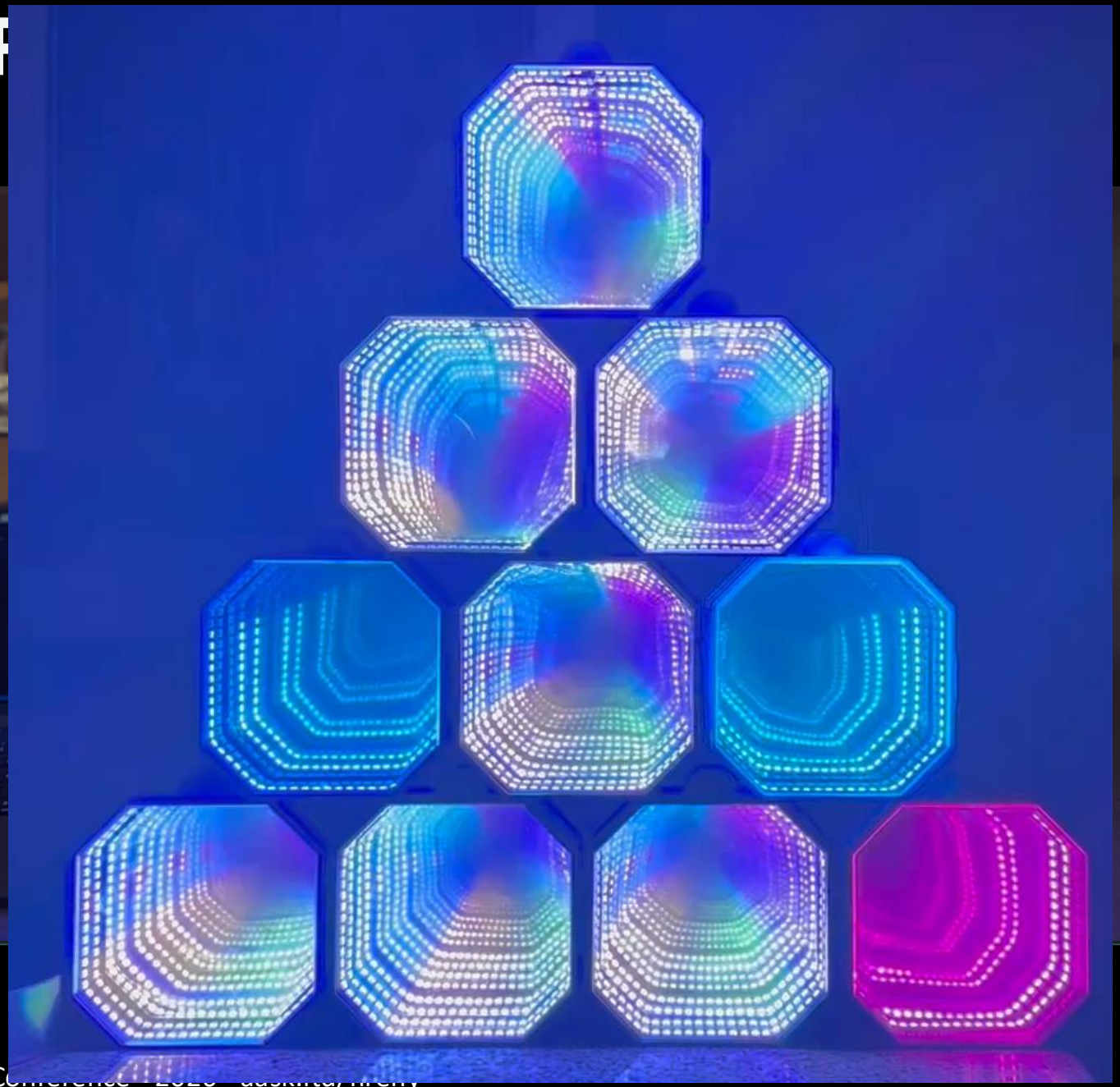
The obsession

Why lights no flashy together

Clocks, badges, and devices with SAO headers

I HAVE SO MANY OF THEM





14

mirrors for Iowa FIRST Tech Challenge

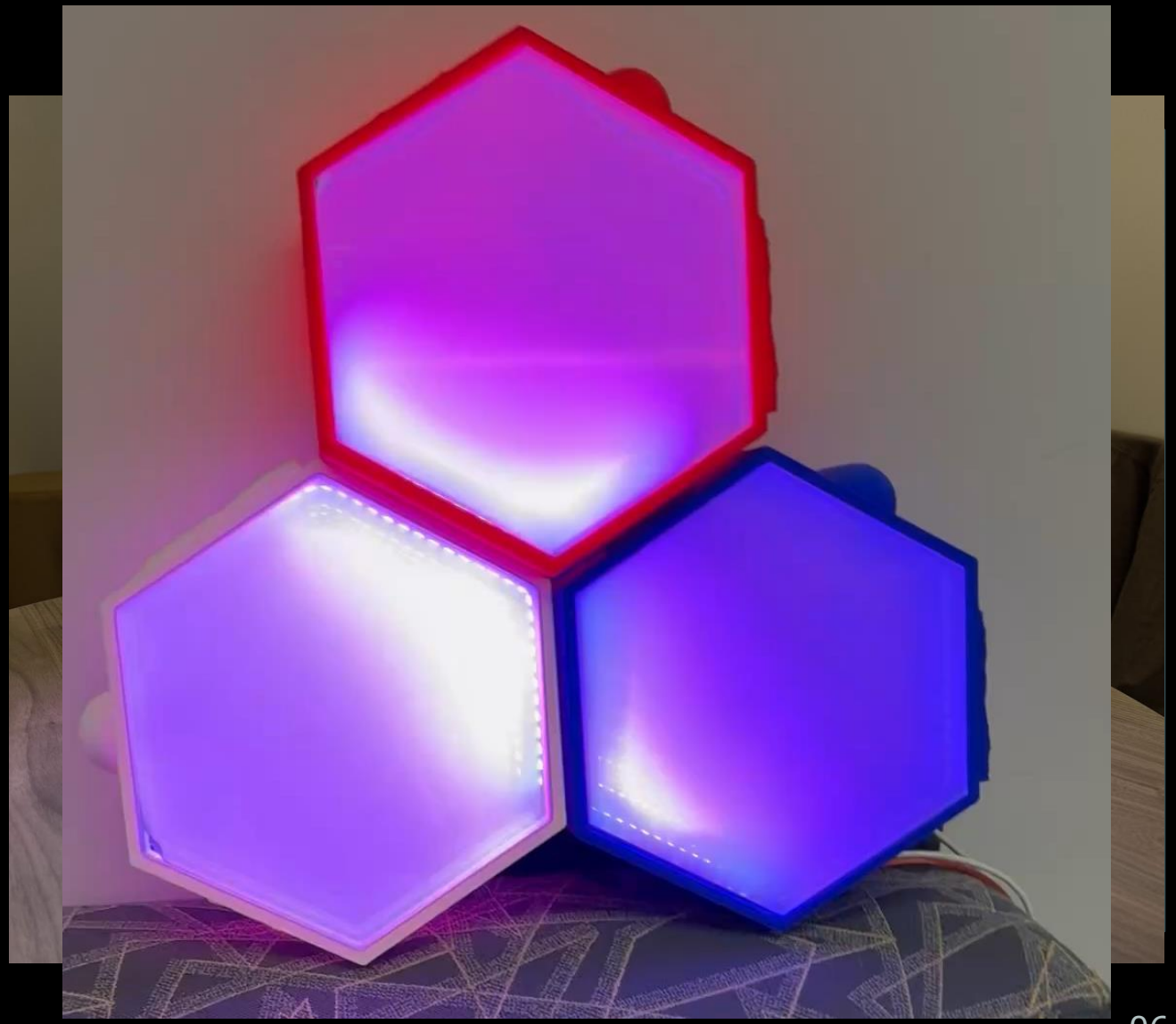
Scoreboard-triggered win notifications

The Texas Trophies

4

custom versions for FTC Super State

Yes, they were super pretty.



“Mostly in sync” still looked wrong

The clocks (or something else) drifted

The frames got out of sync

Still tho, all running MicroPython
– Students could READ it



Then we made them badge-sized

120

Devices Made

No dedicated RTC on board



While running
The clock drifted

After power-off
The timing state disappeared

What I tried, and what I saw

Approach	The Setup	What I observed
Internal RTC-based triggers	No centralized RTC Same-frame triggers	Drift during use Lost timing after power-off
ESP-NOW	Main unit broadcasts Child devices reply	Vendor-frame byte caused crashes or lockups
Browser serial + NTP	Several laptops Browser-based serial	Drift remained visible to the human eye
MQTT	Pub/Sub model on Wifi	Latency in processing triggers
Atomic Clock	Listen to LONG wave	Ferrite core antenna heavy Long sync time

What others have done

Approach	The Setup	Why it doesn’t work for me
InfraRed	No dedicated RTC Control with BIG IR bulb	Requires BIG IR bulbs and $$$
GPS	Outdoor synced signal from the sky	Requires the sky
One batch synced RTC	Custom one-time provisioned clocks	One off, too small

THE PROPOSAL

Firefly



source: SmarterEveryDay #274

A common clock read over I2C

Continuously-synced RTC

Forget setting the clock

An idea for an off-the-shelf RTC for Badges and more
Thank you, Destin for Lighting Bug video and giving me the idea!

How Firefly would synchronize

Proposed behavior

01 **Factory synchronization**

Provision the RTC and authorized update credentials

02 **Authorized field update**

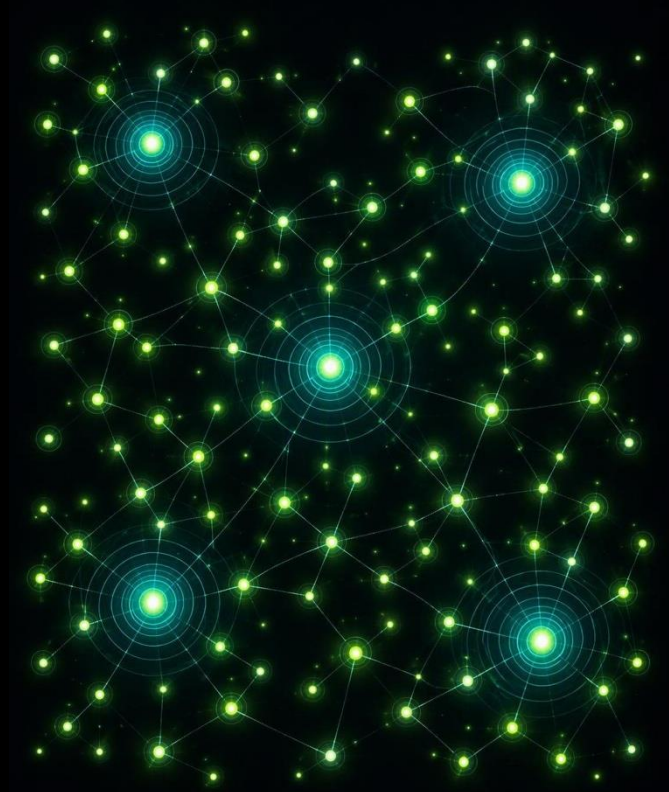
Verify the “grandfather clock” message with HMAC

03 **Clock correction**

Apply a trusted update to the module’s clock state

04 **Host synchronization**

Read time over I2C and follow a shared frame schedule



The target still needs validation



Open design questions

Clock accuracy and standby power

Recovery and correction at power-up

Secure authentication & provisioning

Same-frame behavior across devices

The badge-maker dream

ONE clock

ONE animation



Across different badge designs

What are the applications? ENDLESS!

Everyone has a different idea of what they could use this for

You could…Identify devices in a video feed, and the crowd becomes a display.

01

Short pulses to map

Brief flashes let each device learn its position

02

Pixel-perfect shows

Assign each position its pixel, then play one shared light show

03

Waves of light

Ripple a color animations across the whole crowd

04

Messages across the crowd

Spell words and symbols using each device as a pixel

Which means we could send DT a message:

“We’ve been trying to reach you about your DEF CON’s extended warranty.”



Where I am, and where I want to go

NOW

Hardware experiments, ‘Standard’ Design

I’m testing hardware and sorting the puzzle

NEXT

A small batch for my badges

Prove synchronization across my collection, patch code for old badges

ASPIRATION

DEF CON 36 proof of concept

Pop-out I2C add-on/SAO and location-based beacon puzzle

AFTER THAT

Micro Center shelves

Retail availability the following whenever? if this works…

I could do this myself.
I don’t want to do that to future Amelia.

Hardware and power

Firmware and timing

Authentication design

Testing across badges

Website: https://aask.ltd
Email: me@aask.ltd

Let’s work together. **-Aask Questions**