Rethinking Connectivity in Agriculture
an Avena use case

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What is Avena?

Avena is an open source software and communication stack

It's not intended as a commercial product (but could be used in one)

Our goal: architecture research and disruption

We eat our own dog food:

- ISOBlue
- Purdue OATS DataStation (POD)
- Data Diode (connectivity)
- ... future edge computing research ...
Avena design goal

Create opportunity.
Borrowing ideas: Be a matchmaker

Android is an open source software stack created for a wide array of devices with different form factors. Android's primary purpose is to create an open software platform available for carriers, OEMs, and developers to make their innovative ideas a reality and to introduce a successful, real-world product that improves the mobile experience for users.

Android is designed so that there's no central point of failure, where one industry player restricts or controls the innovations of another. The result is a full, production-quality consumer product with source code open for customization and porting.

https://source.android.com/docs/setup/about
Borrowing ideas: Be the matchmaker

Android abstracts *hardware vendors from software vendors* via a standard API.

Android’s pre-competitive interface enables a much larger market than one of the vendors could create alone.

*Consider:* What happened to Windows phones? Blackberry? Tizen?

**Why not just use Android?**
Android focus on devices. Avena focuses on a full system of things (including Android things).

**Already partly there?**
Avena on a Deere MTG?
Avena design goal
Build software local first.
Yesterday's future is now
...except when it isn't

In agriculture, network outage is not *exceptional*, it is *typical*.

Things can't just *stop* because the network goes away!
NATS is an open source project that passes messages between a set of publishers and subscribers.

Publishers and subscribers don't know about each other.

Subjects

Message

Action

PUBLISH j1939.pto
{ time: 15, speed: 1200, units: RPM }

PUBLISH j1939.pos
{ time: 15, speed: 4, lat: 40.41, lon: -86.8 }

PUBLISH gps.pos
{ time: 15, speed: 4, lat: 40.4, lon: -86.9 }
Aside: NATS
Publish and subscribe

- PUBLISH j1939.pto
  { time: 15, speed: 1200, units: RPM }

- PUBLISH j1939.pos
  { time: 15, speed: 4, lat: 40.41, lon: -86.8 }

- PUBLISH gps.pos
  { time: 15, speed: 4, lat: 40.4, lon: -86.9 }

- SUBSCRIBE gps.pos
- SUBSCRIBE *.pos
- SUBSCRIBE j1938.pto
Aside: NATS
Publish and subscribe

PUBLISH `j1939.pto`
{ time: 15, speed: 1200, units: RPM }

PUBLISH `j1939.pos`
{ time: 15, speed: 4, lat: 40.41, lon: -86.8 }

PUBLISH `gps.pos`
{ time: 15, speed: 4, lat: 40.4, lon: -86.9 }

SUBSCRIBE `gps.pos`

SUBSCRIBE `*.pos`

SUBSCRIBE `j1938.pto`
Aside: NATS
Publish and subscribe

- **PUBLISH** `j1939.pto`
  
  `{ time: 15, speed: 1200, units: RPM }`

- **PUBLISH** `j1939.pos`
  
  `{ time: 15, speed: 4, lat: 40.41, lon: -86.8 }`

- **PUBLISH** `gps.pos`
  
  `{ time: 15, speed: 4, lat: 40.4, lon: -86.9 }`
Aside: NATS
Request + Reply

Also known as a Remote Procedure Call (RPC)
or
Command and Control

REQUEST back50.irrigator.state
   Reply: _INBOX.fFKxir934
       { action: turn-on, amount: .5 inch }

SUBSCRIBE _INBOX.fFKxir934

SUBSCRIBE back50.irrigator.state

PUBLISH _INBOX.fFKxir934
    { state: on, left: .5 inch }
Aside: NATS
It's NATS all the way down

"Leaf nodes" are filtered and permissioned

Inner-NATS networks are transparent

PUB back50.irrigator.status

SUB back50.irrigator.status

PUB cnh310.machine.fuel-level

SUB frank-farms.cnh310.machine.fuel-level

PUB back50.irrigator.status
Aside: NATS

Interest graphs

Services receive data by “demanding” it through a subscription pattern.

The cumulative interest in subjects is communicated to peer NATS servers.

NATS *only* sends messages to peers that have interest in the data.
Avena on the device

Avena devices have computing and a local NATS

Function is not dependent upon external connectivity
Avena design goal
Connect the things.
Avena connects the farm
Avena connects partners
Avena connects industry
Avena connects industry
Avena design goal

Interoperability is message passing.
(and also how one solves distributed system)
Messages are the data.

Based on leading distributed system design patterns, we lean on sharing messages, not data files.

Data files should be created by the consumer, however best fits their needs.
It is more than NATS

NATS provides many positive benefits and is an excellent base, but Avena events...

- Need standardized schemas
- Need standardized subjects
- Need distributed tolerant timestamps (global order)
- Must be secure and allow for (distributed + disconnected) permissions
- Opportunistically move messages even when connections are unstable
- Services must be discoverable
- Etc.
Avena design goal
Software doesn't know about the physical network
Software can not be *burdened* with this complexity!

Overlay networks with logical addressing (subjects), simplifies development.
NATS is Avena’s “logical” or overlay network

However, Avena implementations must abstract physical networks that it supports (think camera sensor)
Physical network

Research Question
How best to route messages?
Avena design goal (we think?)

Ag networks should be opportunistic.

"Delay tolerant"
Physical network
We're already doing it!

Almost done, what's next?

HumanNet

south45
We're already doing it!

Scenario: What if voice calls won't go through?

Almost done, what's next?

Opportunistically select text message network

HumanNet
We're already doing it!

Scenario: What if no cell at all?

Physically move message to the field, and use the "local voice" network
We're already doing it!

Scenario: What if voice calls won't go through? (alternative)

Relay message to seed tender, seed tender physically moves message to the field, and uses the "local voice" network.

More effective routing algorithm.
Ag is a distributed system
Always has been.
Always will be (probably).
Almost demo time
DEMO: ISOBlue and Avena in action

Go to: avena.oatscenter.org
Open Source: github.com/oats-center/avena-app
Password: iot4ag
Only need to add your code... or blocks!
Only need to add your code... or blocks!

Python code generated from GNURadio Companion
Controlled Data Streaming

SDR FM tuner at ISOBlue

RTP

WebRTC Multimedia gateway in the cloud (server at Purdue)