Using IoT to Turn Analytics Into Farm Implements

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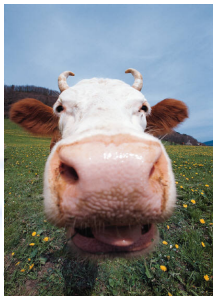
& Rich Wolski

Computer Science Department
UC Santa Barbara

ASME IoT - June 2016



Recent Advances in Computing

- Technology pervades our lives
- Broadens participation
  - Very accessible

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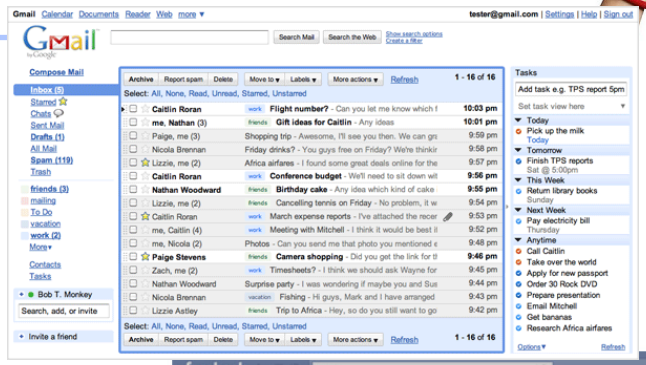

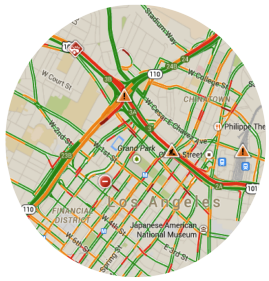

Google

amazon

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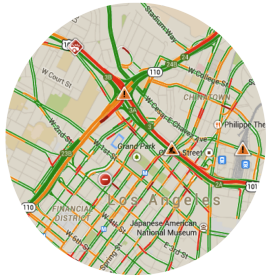
Recent Advances in Computing

- Technology pervades our lives
- Broadens participation
  - Very accessible
- Explosion in data collection



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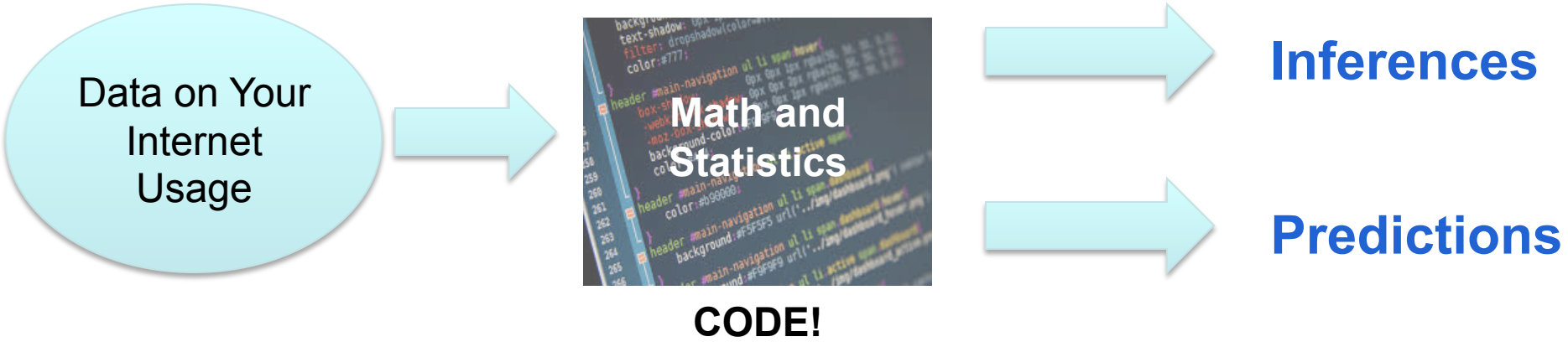
Analytics: Statistical Analysis of Internet Usage



CODE!

- Sales:
  - What **products** you will buy and when you will buy them
- Marketing:
  - **Opinion** shaping
- Politics:
  - Who will vote if contacted **before** the election and for whom

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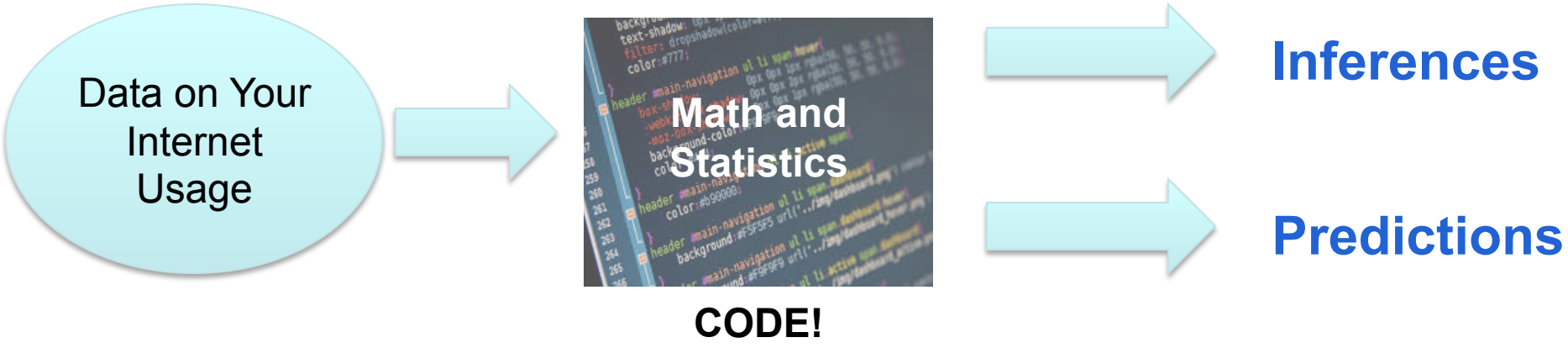
Analytics: Statistical Analysis of Internet Usage



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Data analytics has *transformed* our economy … and turned us into amazing *consumers*

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…Can Analytics Turn Us Into Amazing *Producers*?

- To solve a *very hard*, *impending* problem: **feeding the planet**
  - Understanding is key to Food-Energy-Water management
  - Global: *500M people today are food-insecure
    - *15M US children going hungry tonight;
    - *9B people to feed by 2050

http://www.cdfa.ca.gov/statistics/

http://www.ers.usda.gov/topics/international-markets-trade/global-food-security.aspx

Andrews-Speed et. al 2015

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- Vast amounts of **data** surrounding the crop lifecycle
  - Weather, historical records, sensors, images (NDVI/thermal)
- Yet, the **data analytics** boom has not yet come to Ag
  - Despite the need to increase efficiencies and productivity
    - Do more with less

http://www.cdfa.ca.gov/statistics/

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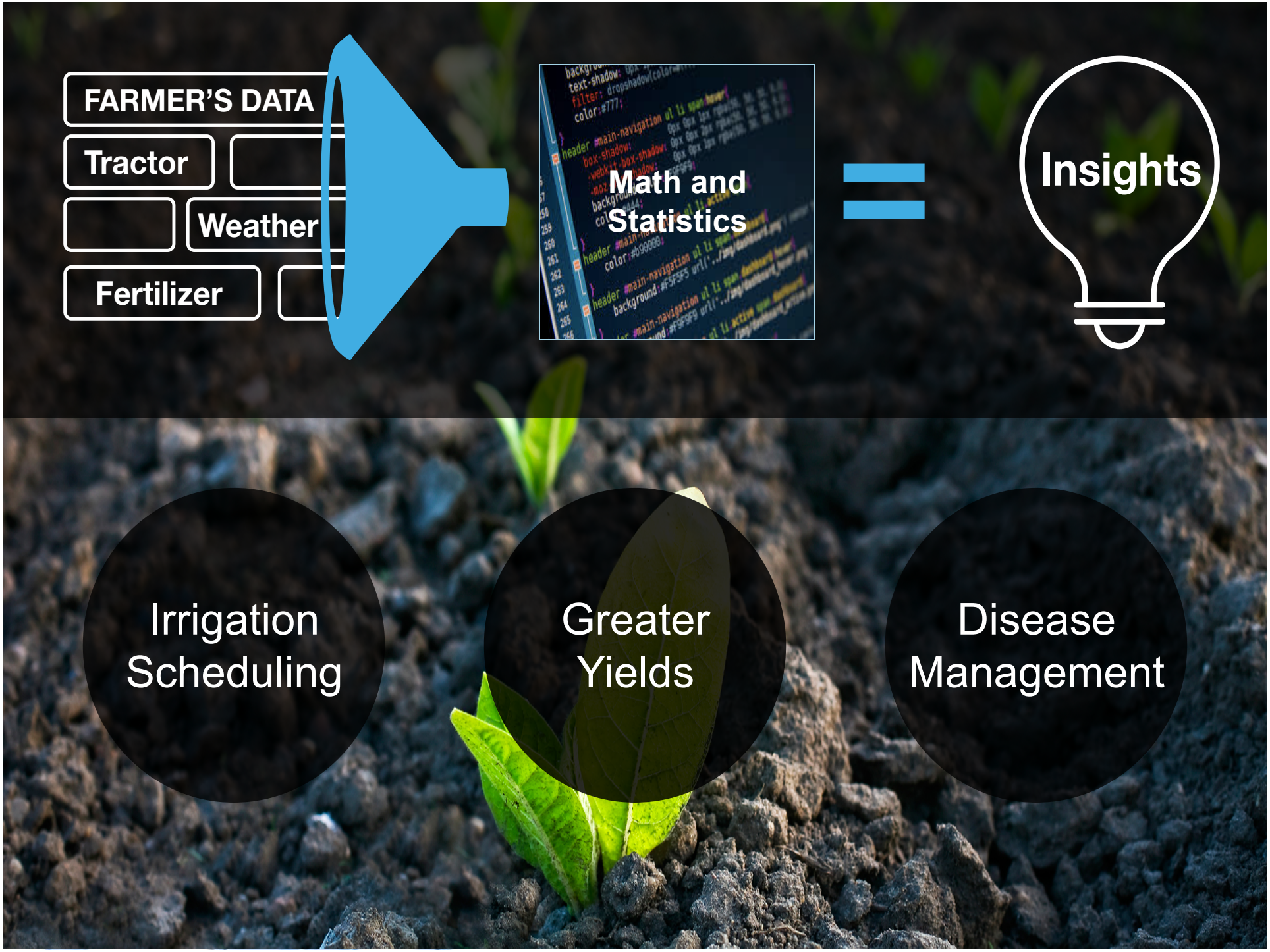
FARMER'S DATA
Tractor
Weather
Fertilizer
Math and Statistics
Insights
Irrigation Scheduling
Greater Yields
Disease Management

Challenges

- Data Acquisition
  - Network connectivity is not ubiquitous
  - Must be fully automated => manual data entry error prone
  - Must be inexpensive at geographic scale
- Data Fusion
  - Sensors, Images, Geo-referencing
- Analytics
  - Inference and predictions are regional => one size does not fit all
- Ease of use
  - Must be simple to extract insights
- Privacy
  - Grower must control what data leaves the farm (if any)

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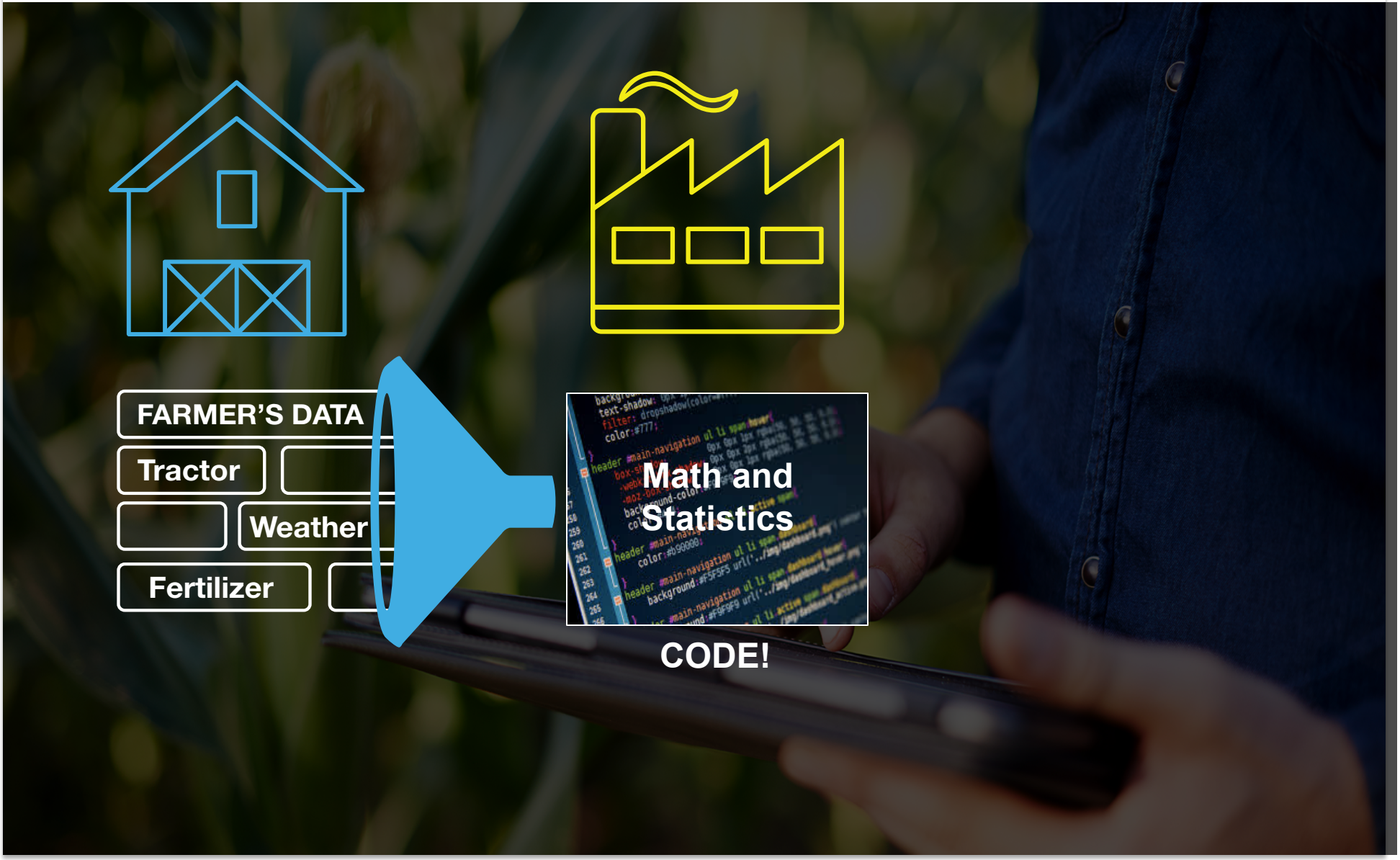
How It Works Today



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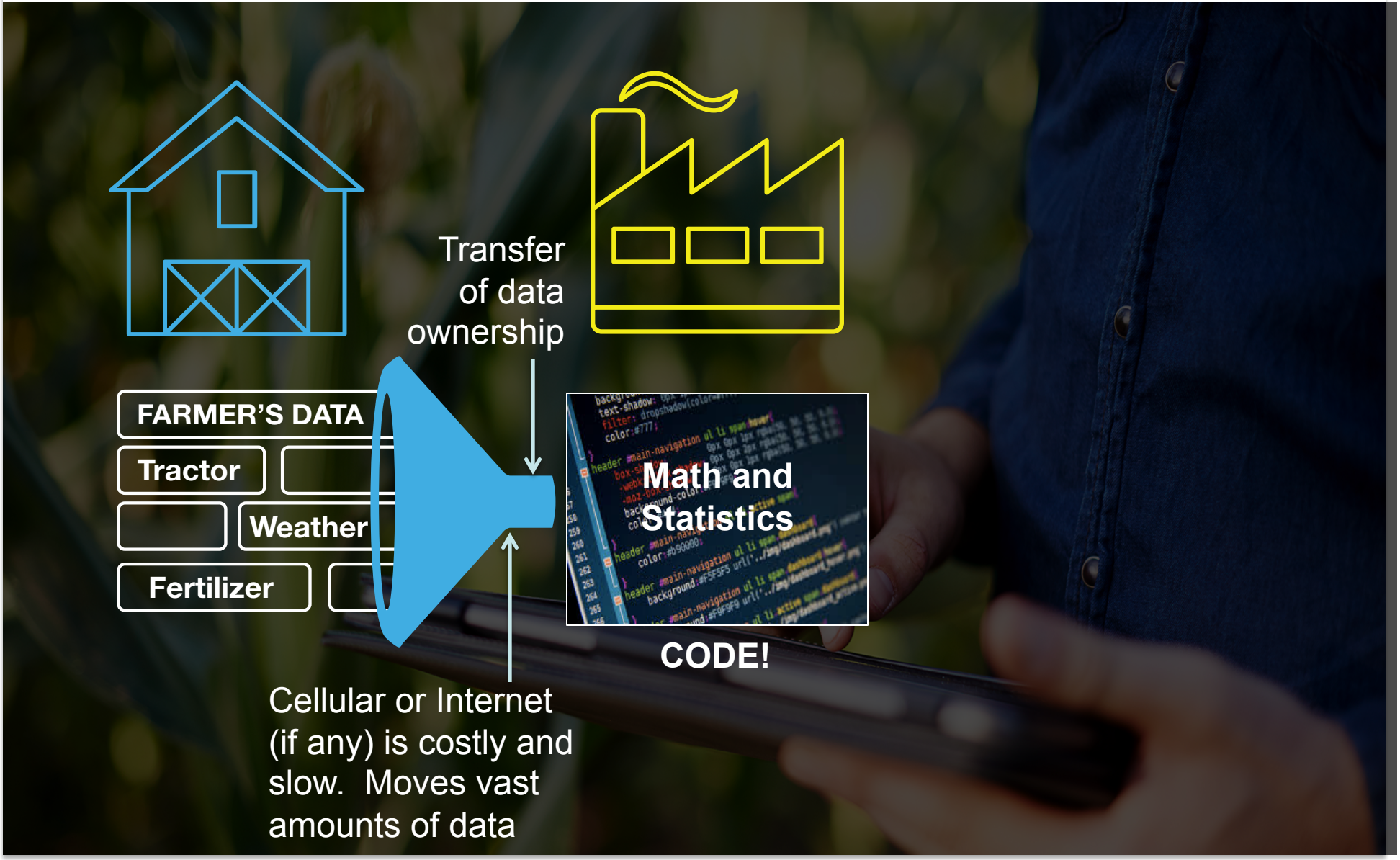

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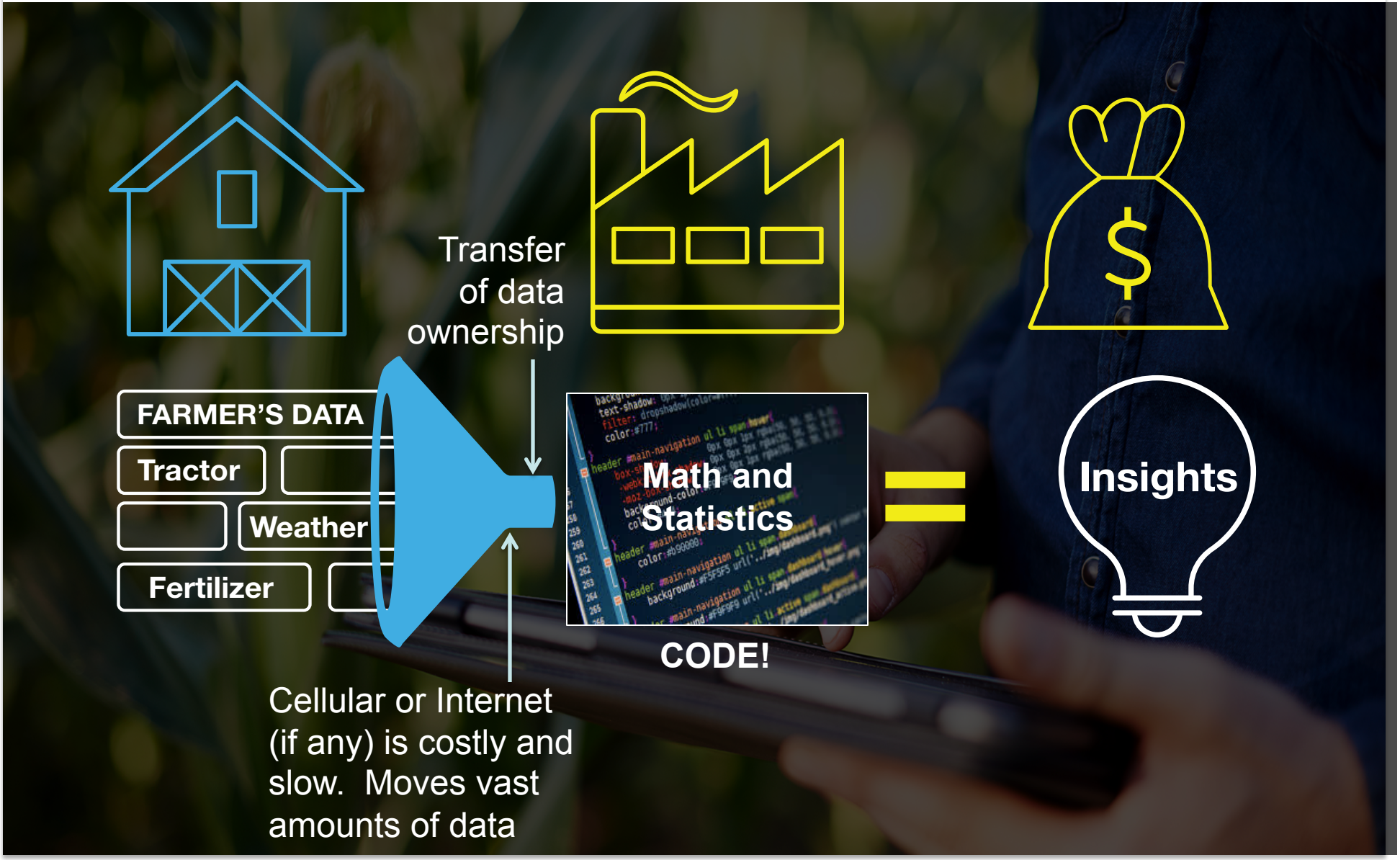

A New Model is Needed

UCSB SmartFarm

- Open source **edge** computing system
  - Data acquisition, fusion, and analytics
  - Highly available and fault tolerant → self maintaining
  - Full control over data sharing and public cloud/network use

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UCSB SmartFarm

On-Farm Analytics Appliance

- Open source **edge** computing system
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- Combines and integrates
  - Cloud infrastructure (Amazon AWS API-compatible)
  - Cloud runtime (Google App Engine API-compatible)
  - Cloud services:
    - Storage (SQL, NoSQL, HDFS)
    - Analytics (Spark/Hadoop, ML, image processing, spatial tools, …)
    - Visualization

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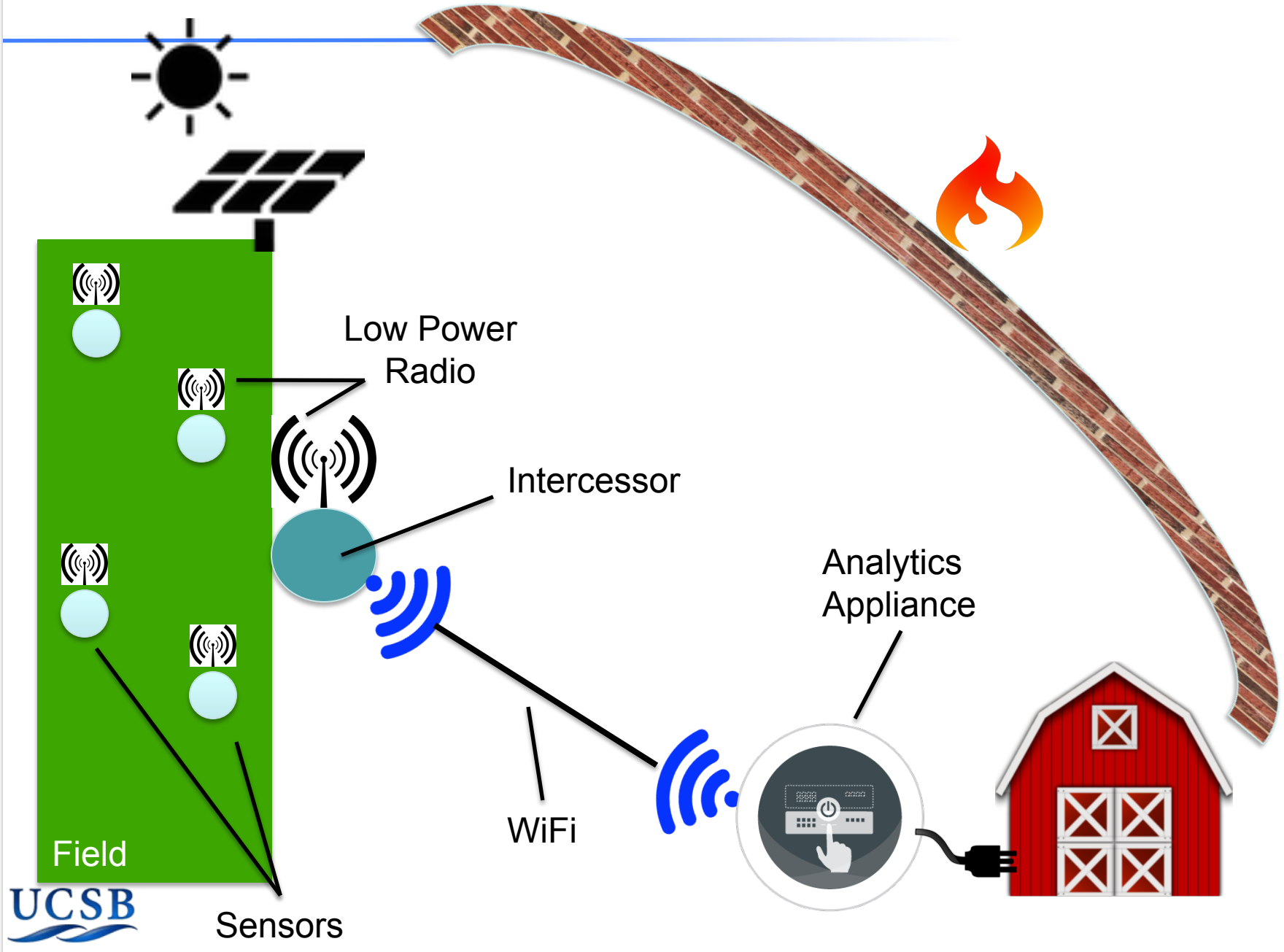
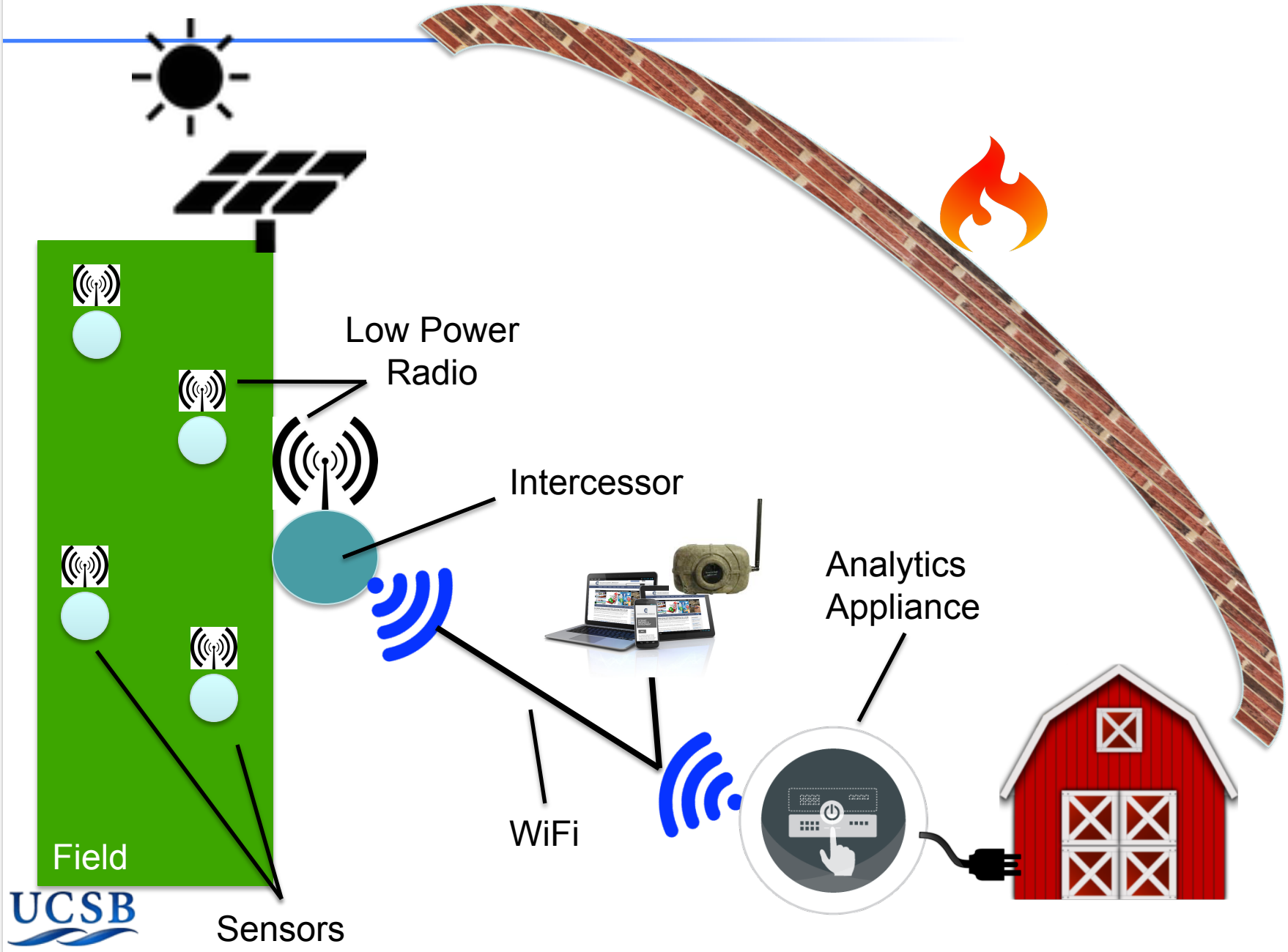
App Store model for decision support and visualization ***apps***

SmartFarm Architecture



SmartFarm Architecture



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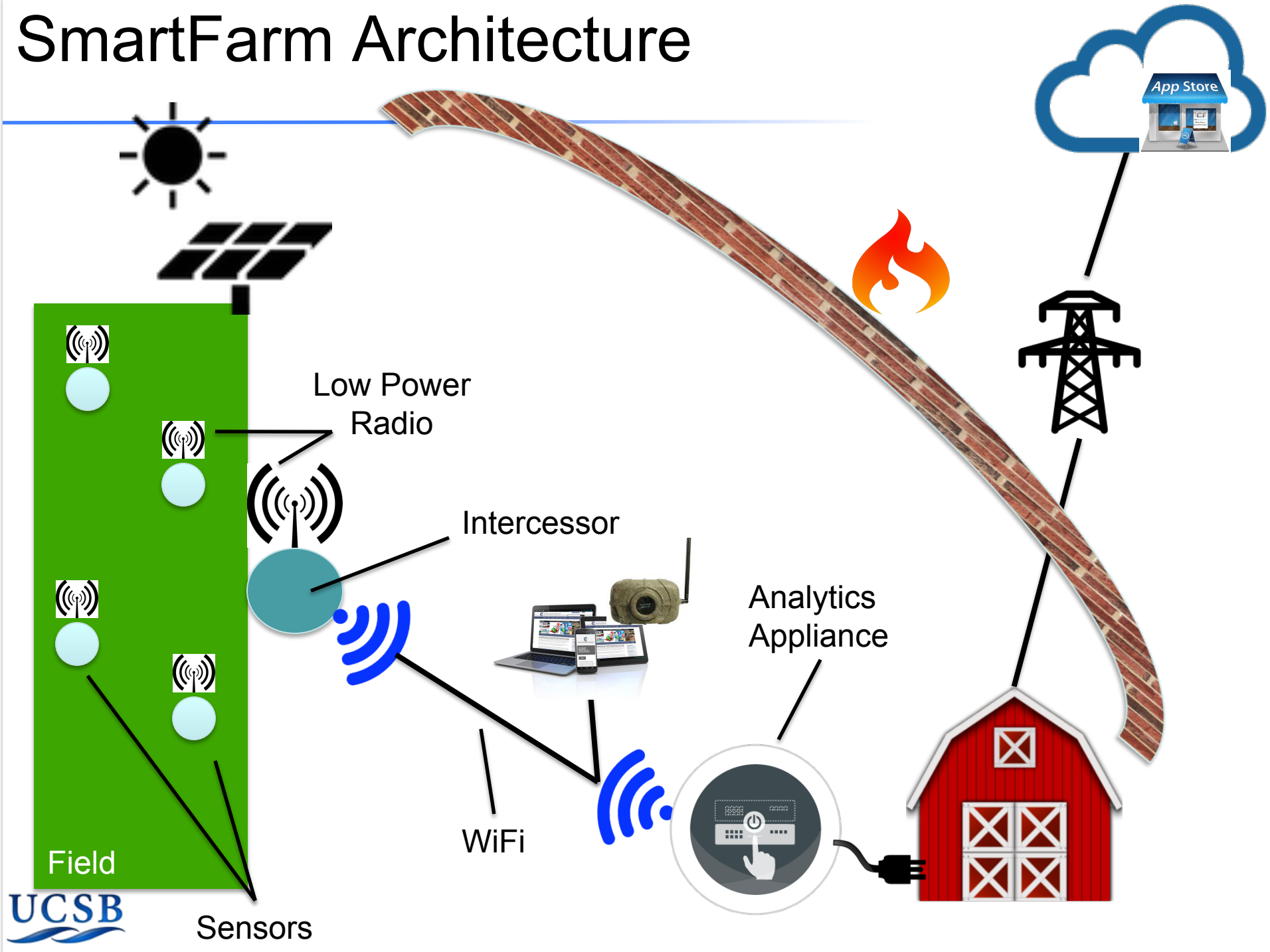
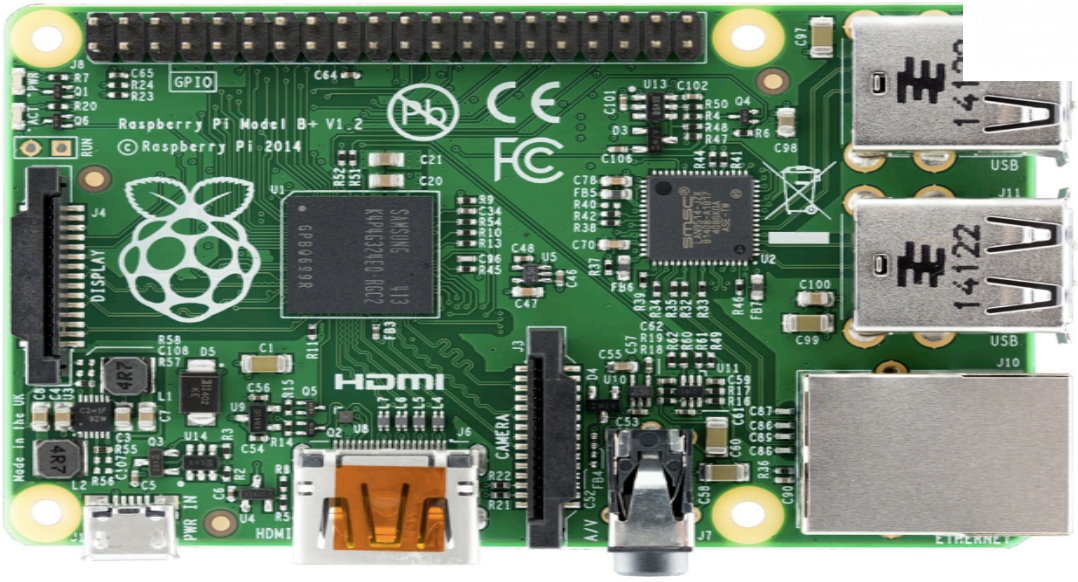


Sensors

- Platform: microcontroller + low power radio
  - Battery or super cap for power storage
  - Solar panel recharges battery
  - Both analog and digital inputs (e.g. SDI-12)

Intercessors

- Platform: Micro PC + low power radio + WiFi
  - Gateway low power radio communications and WiFi
  - Data buffering
  - Power scheduling
  - Batteries + solar, or wired
- SmartFarm Prototype:



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Analytics Appliance

- Platform: Microcloud
  - WiFi and Wired network, Distributed storage, 120 VAC
  - Eucalyptus + AppScale + Hadoop + Spark
  - Pub/Sub and web service hosting
  - HA and “Lights Out” administration

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Analytics Appliance

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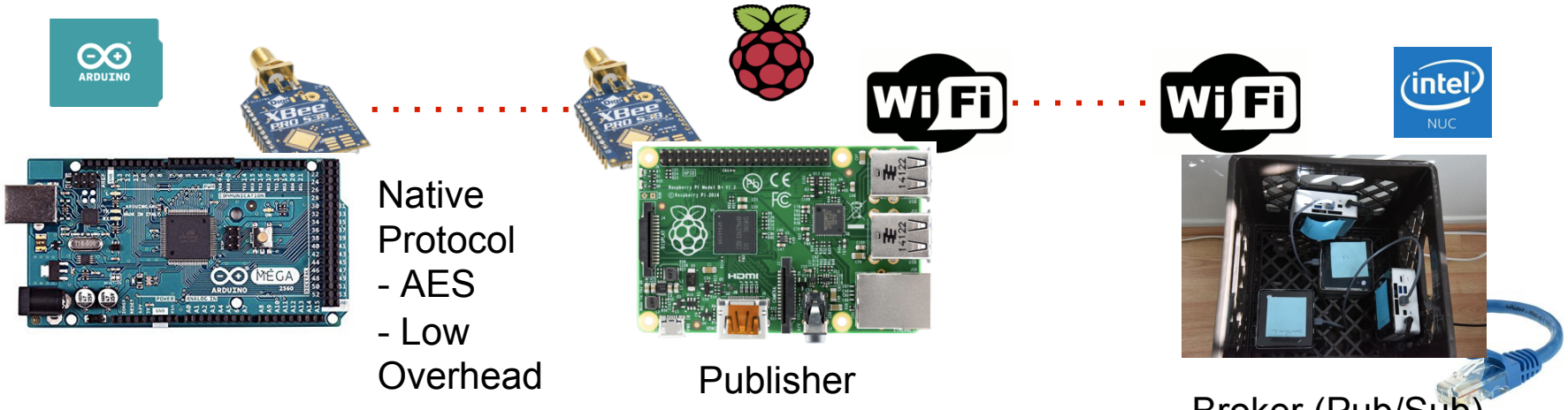
Data Communication

- Inspired by MQTT-SN



Sensor Platform

Intercessor

Microcloud Analytics Appliance

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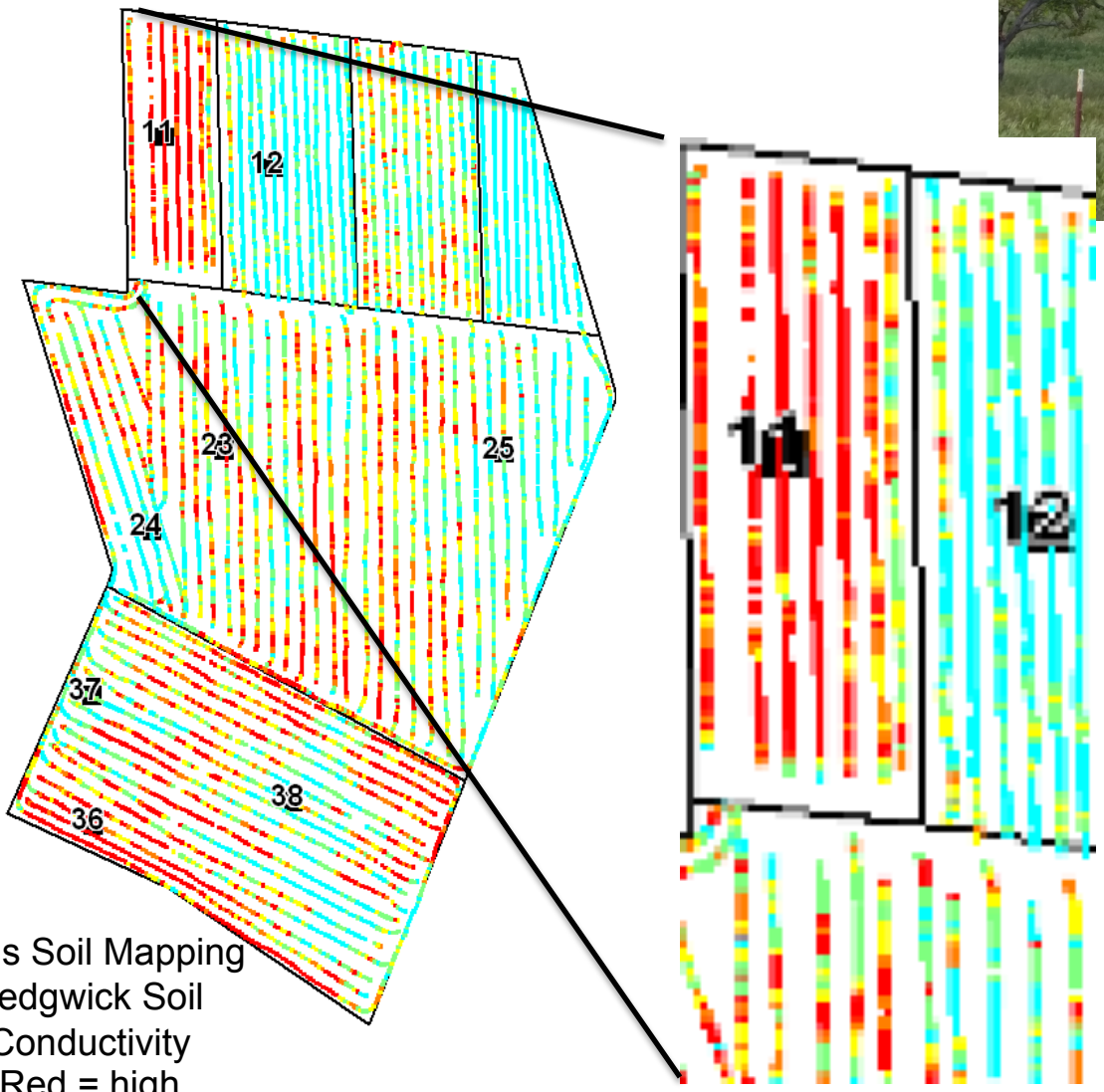
Sedgwick Precision AG



Veris Soil Mapping
Sedgwick Soil
Conductivity
Red = high
Blue = low

Watermark Soil Moisture Sensing

- Sensors at NW and SE corners of the vineyard
- Measure at 1 ft, 2ft, and 3ft depth
- Measure soil temperature at 1ft

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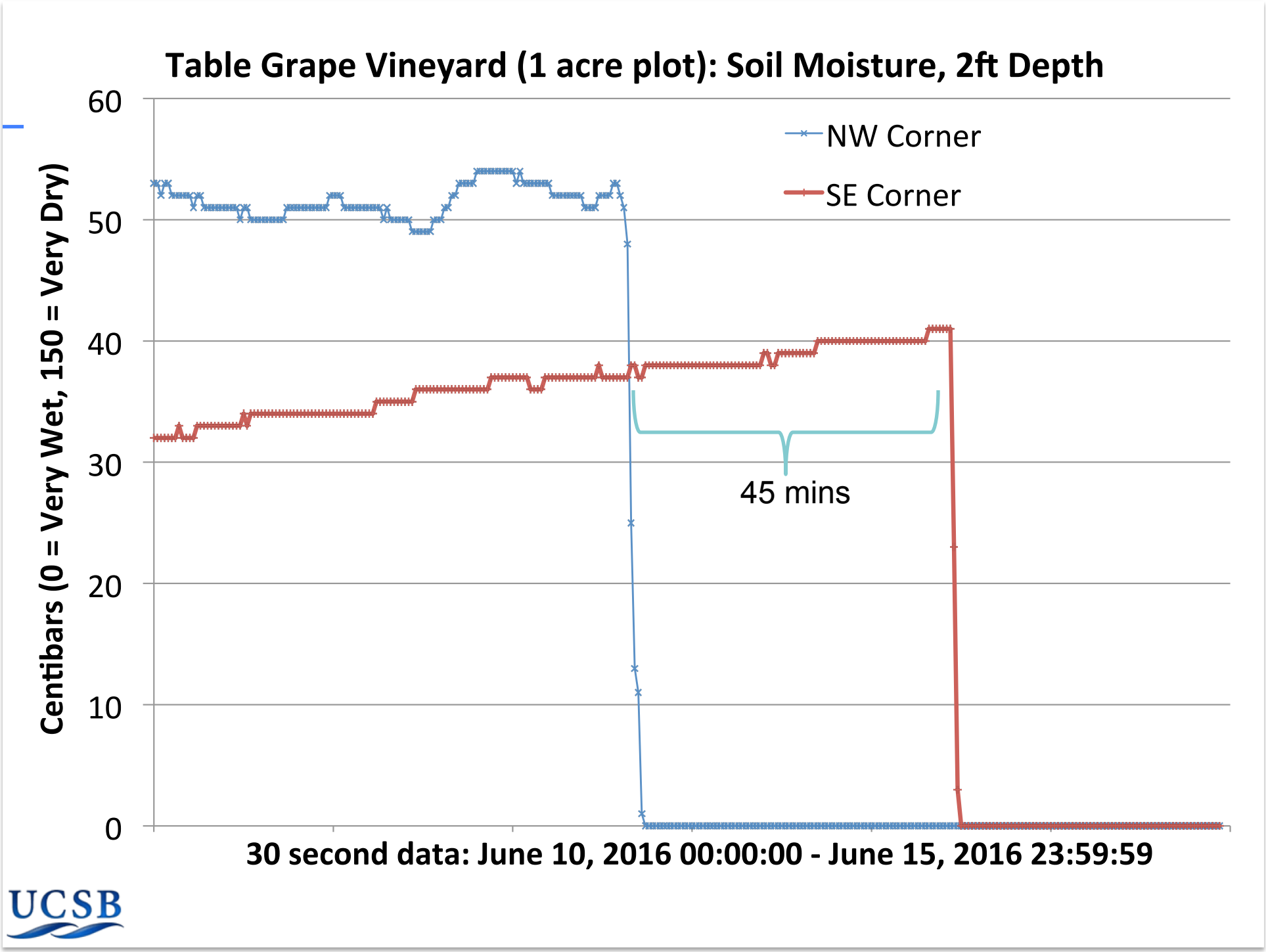
Table Grape Vineyard (1 acre plot): Soil Moisture, 2ft Depth
Centibars (0 = Very Wet, 150 = Very Dry)
60
50
40
30
20
10
0
NW Corner
SE Corner
45 mins
30 second data: June 10, 2016 00:00:00 - June 15, 2016 23:59:59
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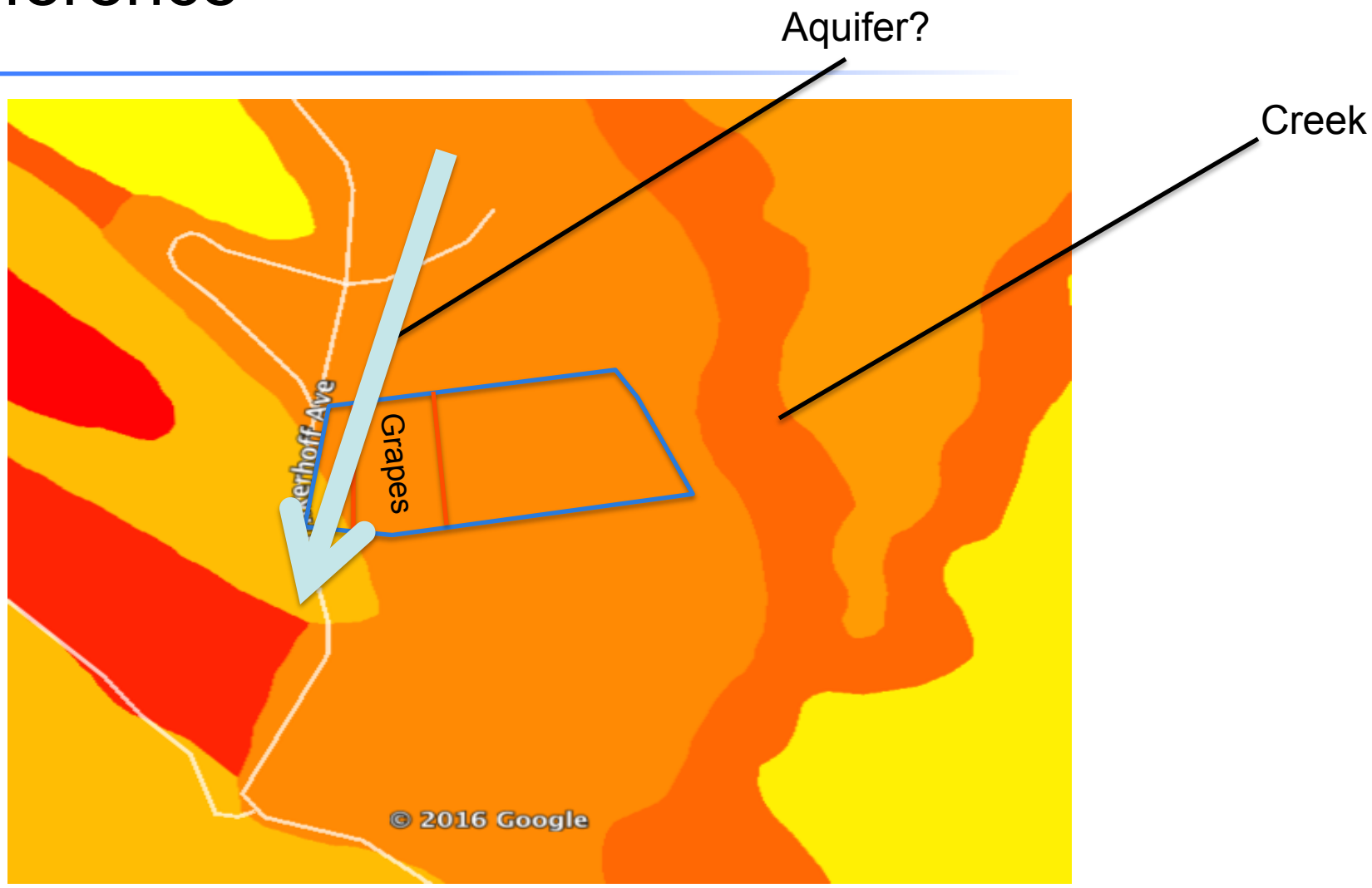
Inference



National Cooperative Soil Survey (SSURGO)

Animal (Camera) Trapping: populations, predators

Where's the Bear?!

Highly Collaborative Research

- Validating research through collaborations with start-ups
  - Innovation partnerships

PowWow

tule

OBSERVANT™

gThrive

TerrAvion

Too Collaborative?

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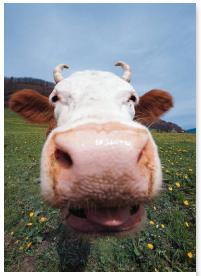
Thanks!



- Recent Student Researchers and Visitors!
  - **Current**: Stratos Dimopoulos, Nevena Golubovic, Hiranya Jayathilaka, Varun Kulkarni, Benji Lampel, Wei-Tsung Lin, Kevin Malta, Greg Parsons, Alex Pucher, Paz Zait-Givon
- Collaborators
  - **Lab Co-Lead: Rich Wolski**
  - Linda Petzold (CSE/UCSB), Andreas Hellander (Uppsala U), Pow Wow Energy, CSU Fresno, Cal Poly SLO, William Sansum Diabetes Center
- Support
  - Google, IBM Research, Huawei, NSF, NIH, California Energy Commission

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