SmartFarm: Computing Research for the Next-Generation of Precision Agriculture

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Precision Agriculture (Ag)

- Adapt farm practices to crop/field variability to increase production
  - Measure & understand variability
  - Use this information to optimize input use
  - Automate some/all of these steps

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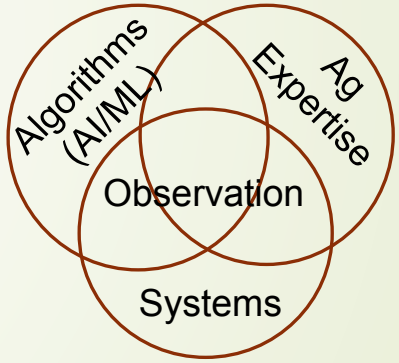

- Computing research
  - Observation (sensing, measuring) & actuation
  - Algorithms: AI, ML, statistical/data analyses
  - Systems: Hardware & software for automation and decision support
  - **Plus** multidisciplinary research collaborations to tailor solutions to Ag

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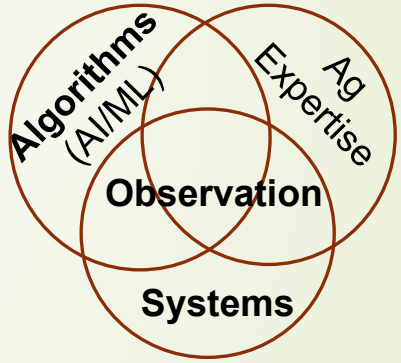

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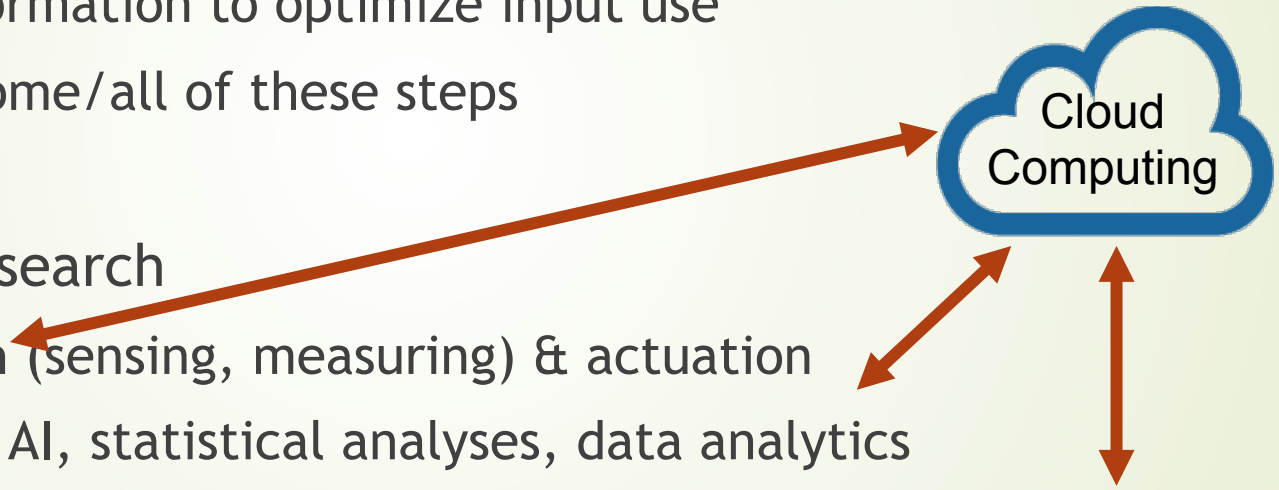

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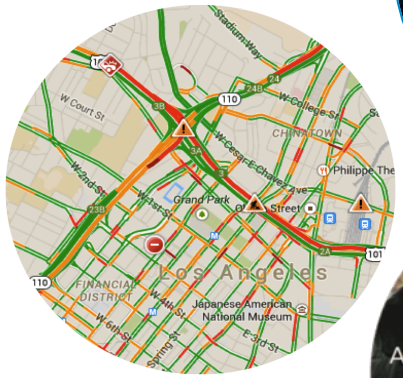
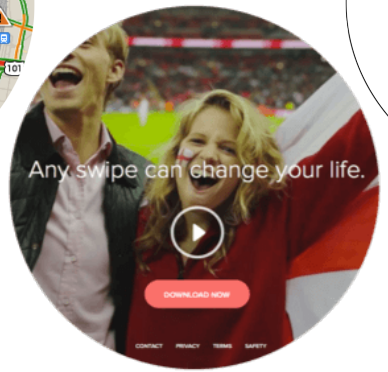
The Cloud + Data Analytics Has Revolutionized E-Commerce





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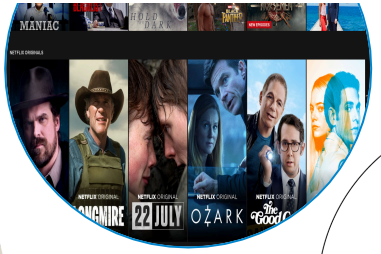
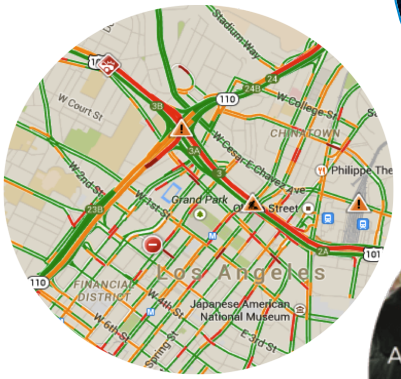
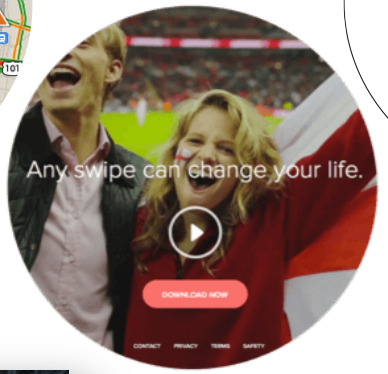
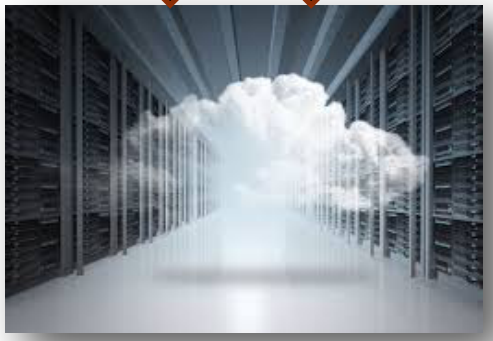
OBSERVATION

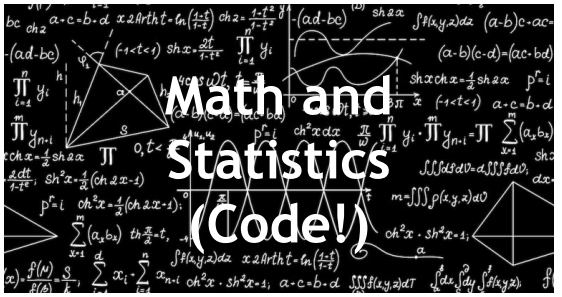








Cloud Computing **Systems**



Algorithms: Inference & Prediction

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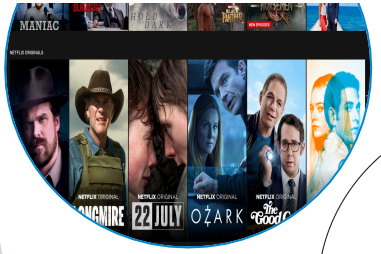

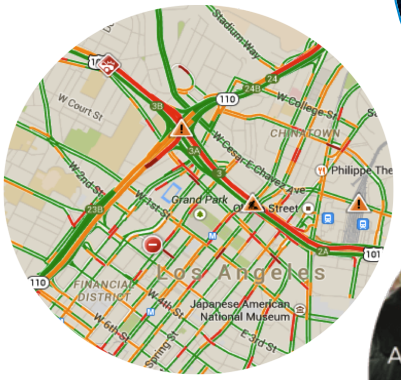

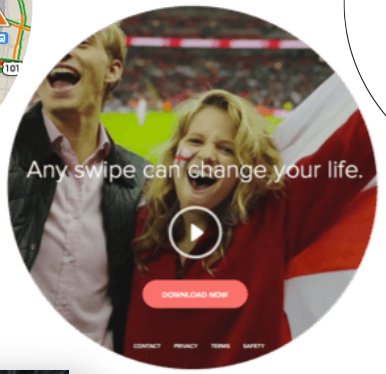

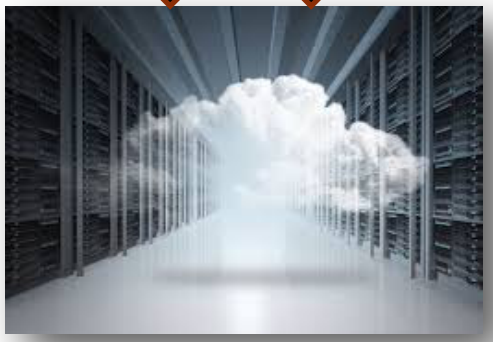

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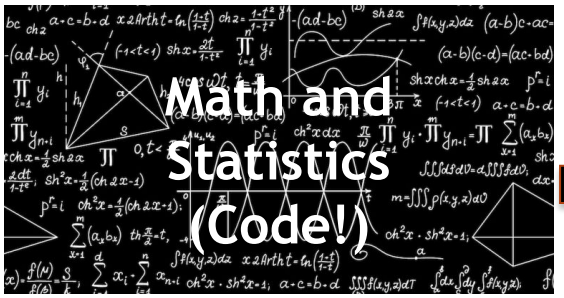

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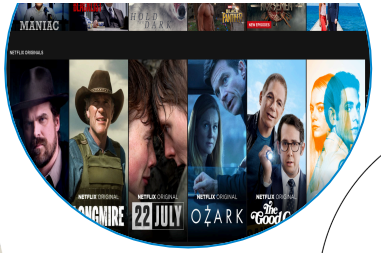
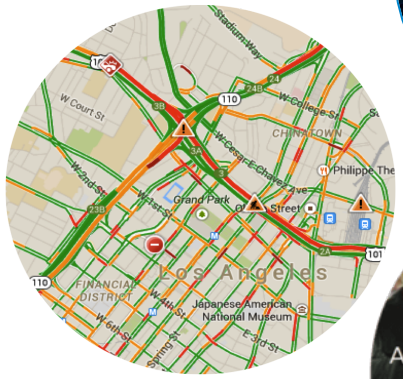
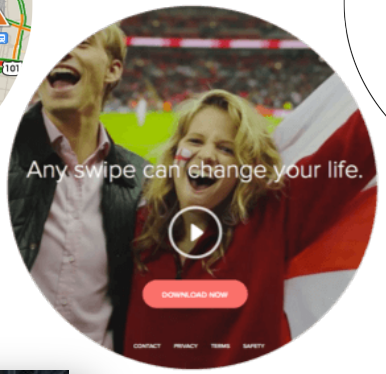
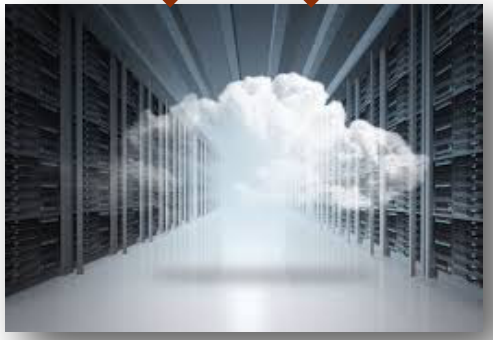






Can we use it to revolutionize agriculture?



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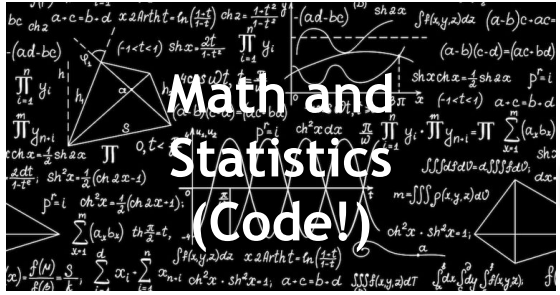

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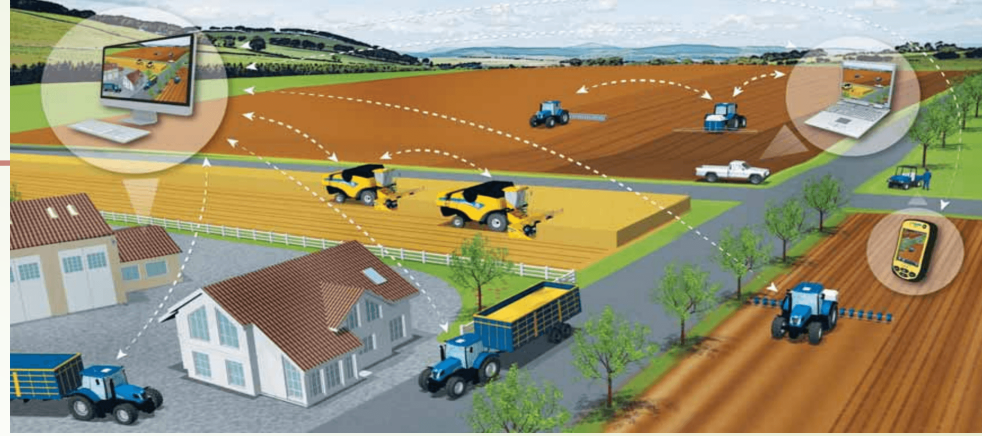
Revolutionizing Precision Ag

- Sensing, measuring, and monitoring
  - Vast amount of data surrounding the crop lifecycle
    - Weather, records, sensors, imagery, …
  - Sense/actuate: Internet of Things (IoT)



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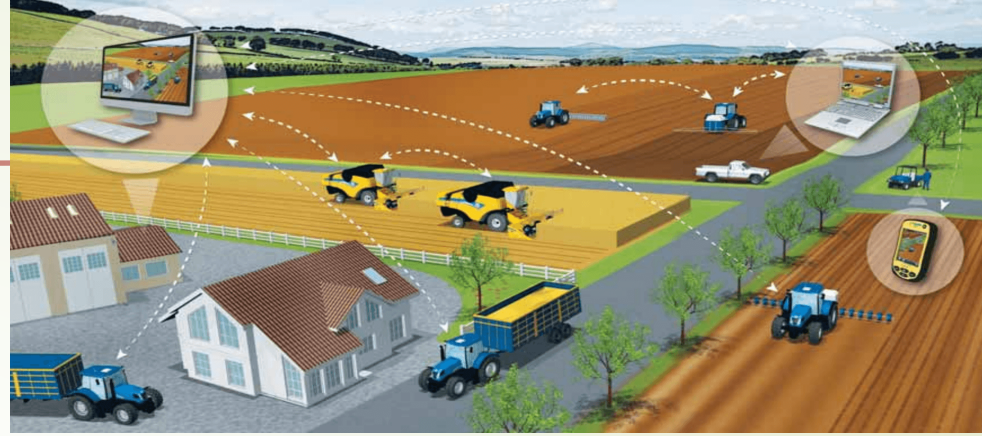

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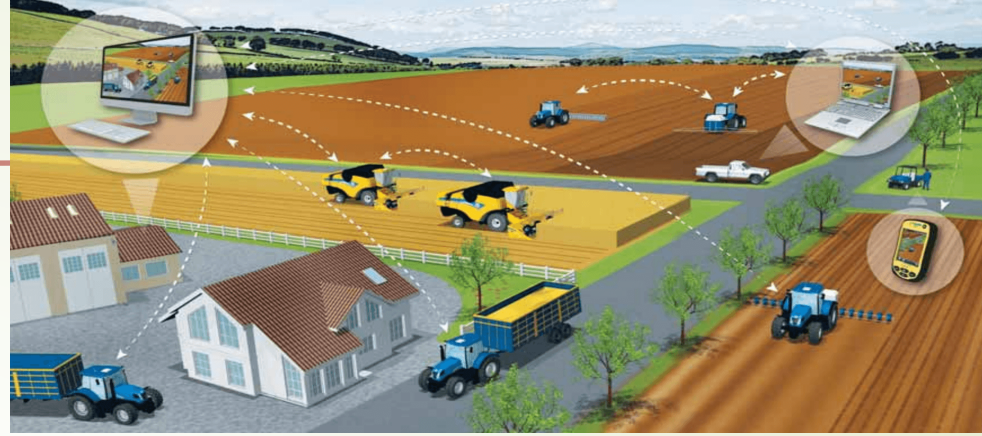

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What about the systems?

Cloud Systems Were Not Designed for Rural Precision Agriculture

- Clouds work for large scale data aggregation, processing, sharing
- Rural precision Ag introduces **new challenges**
  - Vast acreage to sense, measure, monitor, actuate, & automate
    - Sensors/actuators: large in number, very low cost, **battery powered** + solar, resource constrained, in harsh environments
    - Can't ship data to cloud: Radio power goes like the square of the distance
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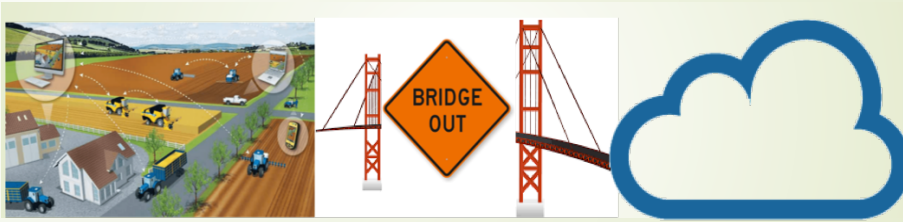
  - Intermittent or no Internet connectivity
  - Data privacy = grower's economic advantage



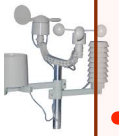
Sensing Tier

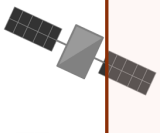
Edge Tier

Our Approach:
Move the cloud (code) to the data

Cloud Tier

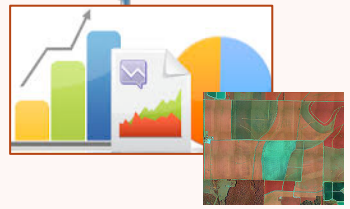








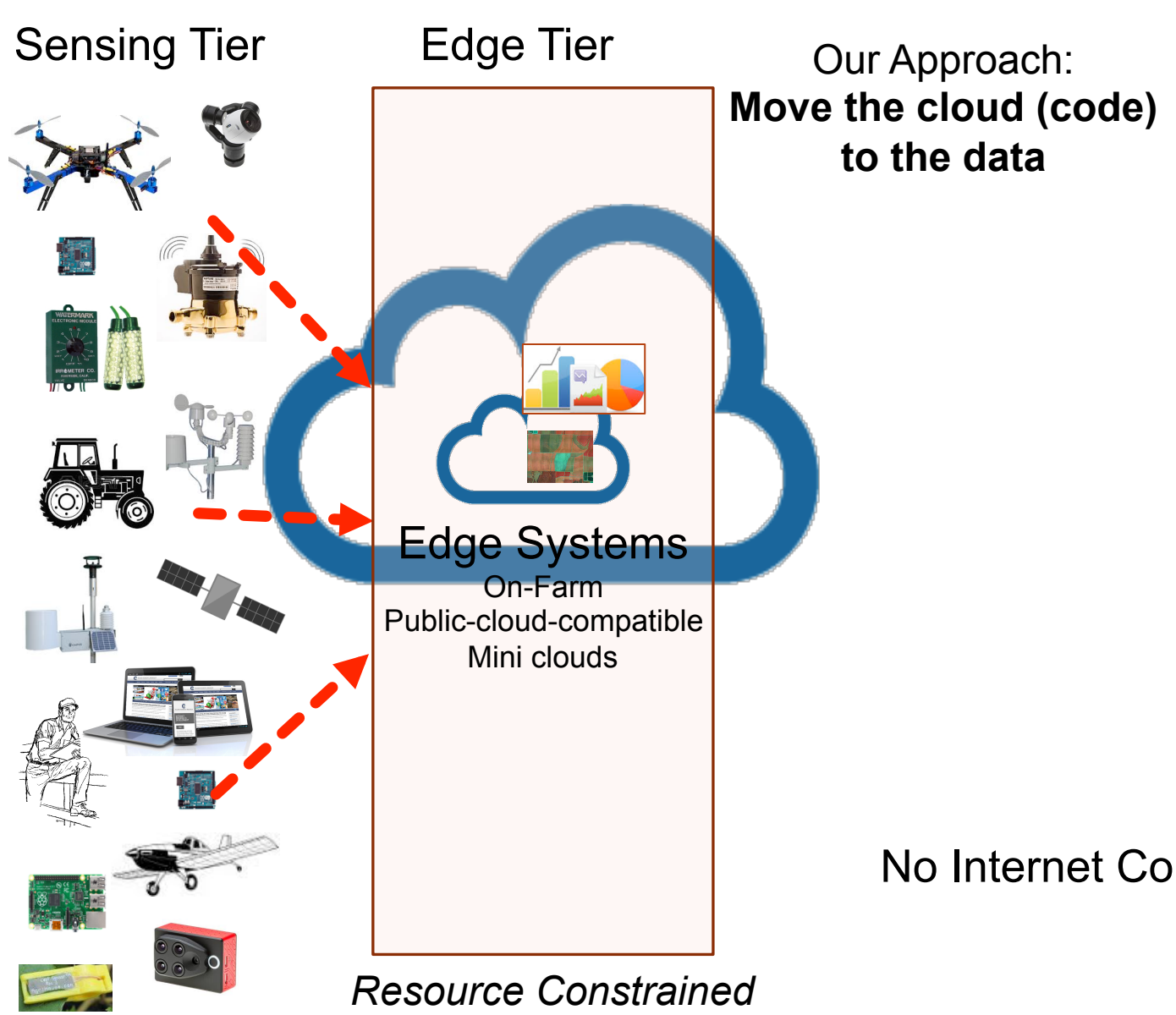
Public Clouds

amazon web services

Microsoft Azure

Google Cloud Platform

Resource Rich



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Move the cloud (code) to the data

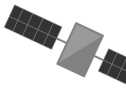
No Internet Connection? No Problem.

Sensing Tier

Edge Tier










Edge Systems

On-Farm

Public-cloud-compatible

Mini clouds

Data travels much shorter distances!


Resource Constrained

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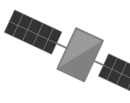
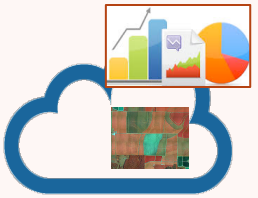
Cloud Tier





Edge Systems

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Grower controls data sharing

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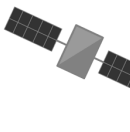


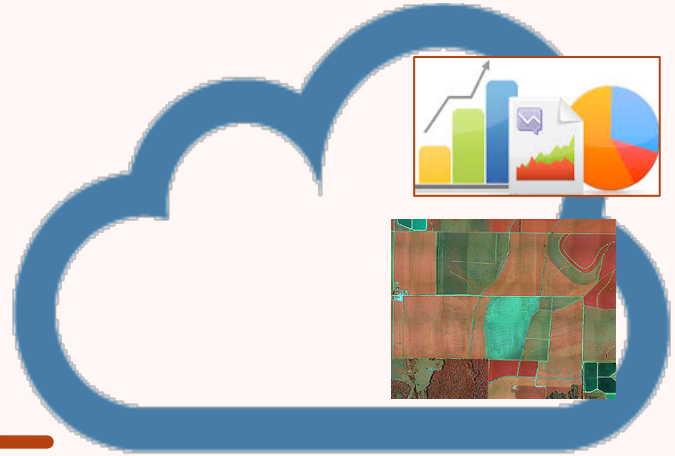



Edge Systems
On-Farm
Public-cloud-compatible
Mini clouds

Grower controls data sharing

Data analytics apps

External data sources



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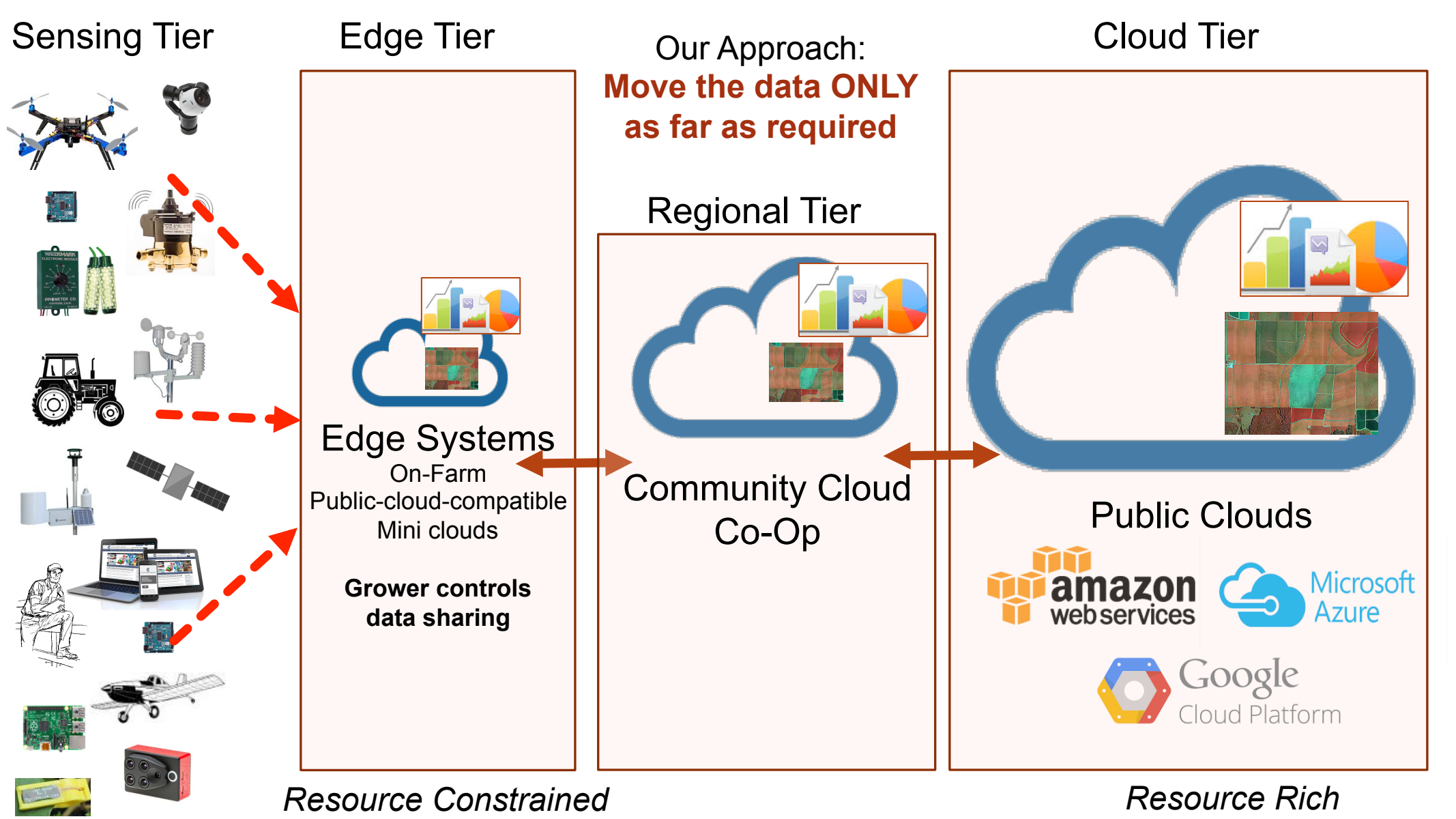
Sensing Tier
Edge Tier
Our Approach:
Move the data ONLY as far as required
Cloud Tier
Regional Tier
Edge Systems
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Public-cloud-compatible
Mini clouds
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Community Cloud Co-Op
Public Clouds
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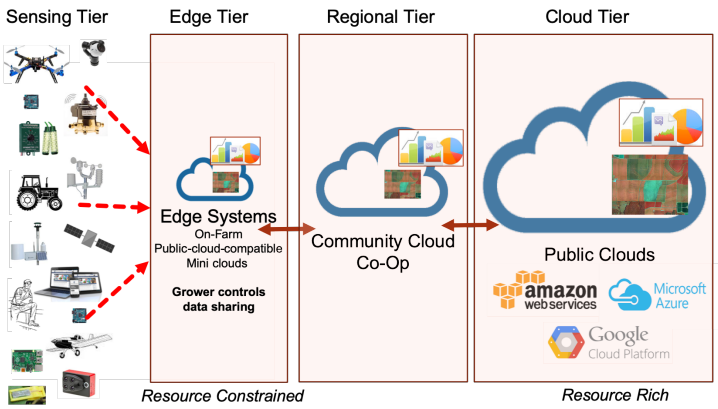
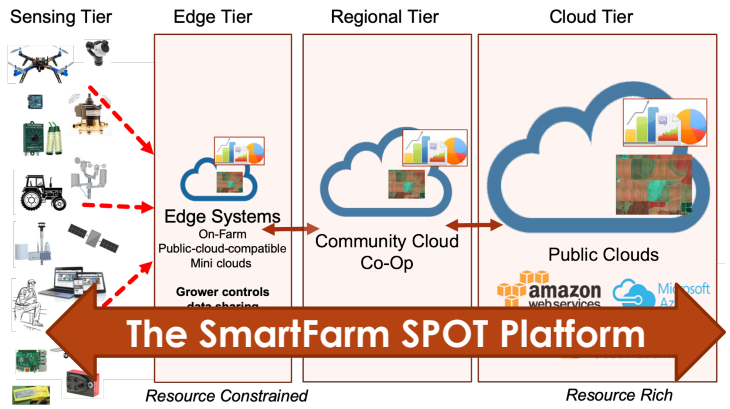
Resource Constrained
Resource Rich

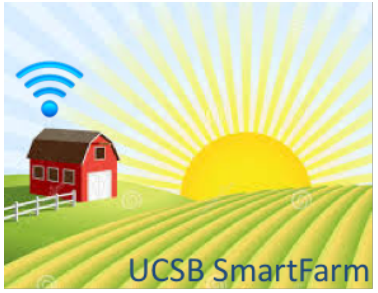
How Can We Write Apps for Such a Complex System?



Goal: Expedite Innovation in Precision Ag

- Our Approach:
- SPOT: Software platform for Apps
  - Apps run on all tiers without modification
  - Security, access, & deployment control
  - ***Designed for on-farm use***
    - *100x more power efficient*
    - Than existing cloud/edge solutions
- **Free & open source**



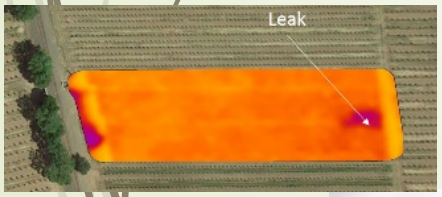


Lessons Learned: The Future of Precision Ag

CS Research for Ag

- Academia has freedom to consider new approaches
  - Cloud works well for some things
  - Domain-specific design = new directions with vast potential
  - Build communities & demonstrable deployments via open source
- Collaborations are key to expediting innovation
  - Across disciplines; academia, government, & industry

Exciting Innovations Just Over the Horizon…



Tracking

A New Kind of Computer Science Research for Ag

Academia + Industry + Government

- Systems + Algorithms + Domain Sci.
- Problem driven & empirical
  - Sustainable, efficient, useful
- Societal & regional impact
- Multidisciplinary collaboration
- Demonstrable, applied, & open
- Engage students & farm communities

UCSB

Thanks!

- **Collaborators:** UCSB, Lindcove REC, CalPoly, Fresno State, UCDavis, UCR, NCState, Powwow Energy, Sedgwick Reserve, Private Growers

- **Support:** NSF, California Energy Commission, NIH, Google, Intel, IBM Research, Microsoft Research, UCSB IEE

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Kerem Celik


Gareth George


Shereen Hussein


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Nazmus Saquib


Michael Zhang

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The Lab for Research on Adaptive Computing Environments
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