Rethinking Communications In Digital Agriculture

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Project 7

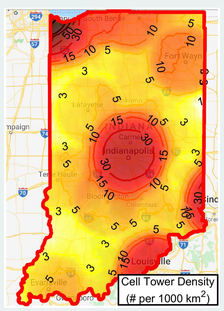
This work presents an analysis of the existing connectivity challenges in agricultural settings and suggests an alternative solution to bridge the connectivity gap. By harnessing the capabilities of the Avena software stack and ISOBlue edge computers for decentralized communication, we propose a method to automate data collection in environments with limited or no connectivity.

Background & Motivation

Why go digital?

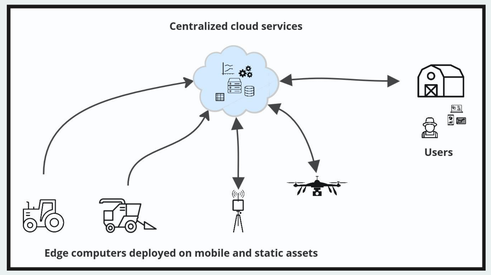
- Data from crops can be used to leverage crop disease research, where most of the data is acquired through controlled experiments or field scouting to outbreak zones.
- Digital agriculture offers technologies and solutions to increase yield productivity by granting farmers more control over their operations via precision agriculture and data-driven tools that support decision making to optimize resource usage in all kinds of operations
- Documented losses ranging from 10.1%, to up to 41.4% in major crops such as wheat, rice, potato, maize, and soybean.
- An increasing world population, which by 2050 is expected to reach 10 billion people, adds more pressure to increase
- yield productivity with limited resources.
- Researchers have been using data analytics to establish an emerging plant disease surveillance network, based on predictive data from transportation networks, domestic global trade networks, among others.

However…



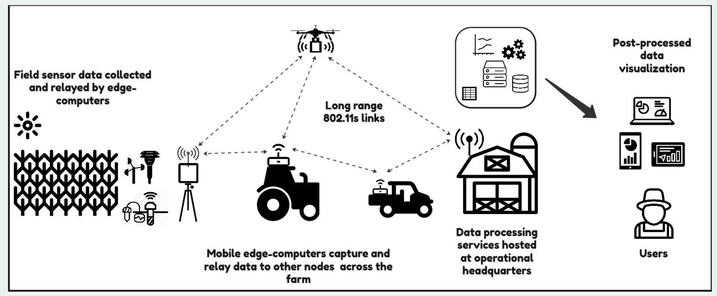
- An important part of the world's population in underconnected (i.e., services with frequent connectivity gaps and data rates below the broadband threshold)
- Cell tower density in rural areas is low. In the state of Indiana, areas outside the urban areas have 3 to 5 cell towers covering areas of up to 1000 km² (Zhang et al., 2021)
- Farmers in remote areas encounter adoption barriers such as high implementation costs, leading to increased crop losses due to reduced decision-making ability.

Is Edge computing local computing?



- Typical edge computing architectures currently use a centralized model, with the "cloud" as the central authority
- Cloud systems are often vendored, i.e., data is transmitted in proprietary formats.
- Low tolerance to connectivity failures
- Transmitting to the cloud increases overhead in communications, i.e., systems need to reach the internet before transmitting.

The Vision



A Delay Tolerant Network (DTN) deployed in an agricultural context, using edge-computers on mobile assets to relay data via long range wireless links, and self-hosted services at the headquarters process data and provide users with analytics to support decision-making

The distributed communications approach in agriculture

Avena ISOBlue NATS

- Avena edge-computing devices abstract data in the form of ***messages*** *and transmit based on* ***interest***
- Data is first stored and/or processed locally, and then transmitted to other nodes, i.e., functions are not dependent upon external connectivity
- Information sharing depends upon message relaying, not large data files.
- Systems understand messages from other systems, and complement their function with more data
- Data is transmitted locally between systems in an opportunistic manner.
- Physical network details are transparent to software.

Future and related work

- Study interactions between entities in agricultural settings for possible communications applications
- Explore different communications technologies for message transmission in agricultural environments
- Survey message formats for data interoperability in agriculture.

Related posters: "OATSMobile: A Data Hub for Rural IoT and Communications"

References: Y. Zhang, D. J. Love, J. V. Krogmeier, C. R. Anderson, R. W. Heath and D. R. Buckmaster, "Challenges and Opportunities of Future Rural Wireless Communications," in IEEE Communications Magazine, vol. 59, no. 12, pp. 16-22, December 2021, doi: 10.1109/MCOM.001.2100280

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