

Reducing Latency: Business Opportunities for Edge Networks in Rural Agriculture

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ABSTRACT: Recent technological advancements have enabled the agricultural industry to utilize artificial intelligence (AI) to improve and automate farms; however, higher latency limits the technology's effectiveness in rural areas, as it causes data computation to take longer. This paper examines the impacts of latency on farms in the United States, explores potential solutions, and identifies opportunities for businesses to address this need. Medium to large farms in the United States are likely to pay monthly for a service that delivers latency-reducing edge networks on-site. The primary research consisted of four interviews with individuals in the AI and agriculture industry, while the secondary research consisted of market reports, case studies, and competitive analysis. The presumed results were that latency is a significant problem. The interviews revealed that latency is not a significant issue; however, the secondary data indicated that latency is a substantial problem with considerable opportunities. After the research was conducted and analysed, the hypothesis was essentially correct. However, what was found was that the target market consists of farms that utilize a significant amount of the technology. The study's results outline a business that can not only benefit the farms but also help combat food insecurity and reduce resource waste.

KEYWORDS: Agriculture, Precision Agriculture, Edge Networks, Edge Computing Solutions, Data Latency Mitigation.

■ Introduction

Artificial intelligence (AI) is rapidly transforming nearly all industries due to its ability to perform tasks more efficiently than humans. However, latency has become a significant issue for many AI adopters, limiting the technology's full potential. The purpose of this paper is to examine the impact of latency on farms in the United States, explore potential solutions, and identify opportunities for businesses to address this need.

Typically, the technology sends data to the cloud for processing, which can take time as the data is processed farther from the hardware. The solution is edge computation, which means bringing the data closer to the devices. Building edge networks on the site of farms enables data to be processed closer to the technology, improving the speed of computation, as visually represented in Figure 1.

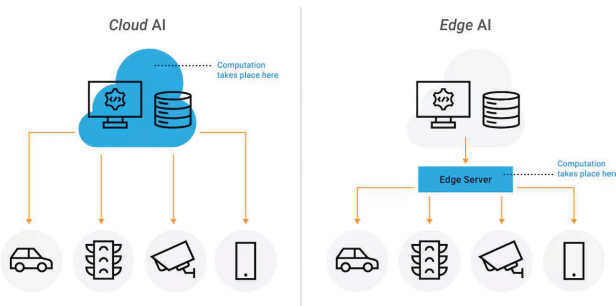


Figure 1: Differences between cloud AI and edge AI.¹ This comparison highlights how edge AI computes closer to the source, reducing latency in contrast to cloud-based systems.

Latency is a problem that, if not addressed, can lead to many more issues, including food insecurity. Latency is the time delay between a cause and the effect, for example, the time it takes

from clicking a link to the page loading. Greater technological latency increases response times, meaning that systems such as an irrigation control react more slowly to changes, which leads to a waste of resources. The world population is projected to reach 9 billion by 2050, which demonstrates that food production will need to increase by 70% by then. If latency is not addressed, achieving this increase in food production by 2050 will be almost impossible.² Additionally, agriculture accounts for 30% of the world's greenhouse gas emissions.² Latency causes a waste of energy and other resources, and the long-term impact of not solving latency is that agriculture will continue to generate large amounts of emissions. This paper examines a minor issue in a niche market; however, the solution to this problem, when applied on a large scale, could have a significant impact on the future.

Furthermore, failing to address the problem could lead to a continued decline in the number of farms in the United States, as illustrated in Figure 2. This decline is problematic because farms play a crucial role in the United States. The agricultural industry provides over 34 million American jobs and, in 2023, contributed \$1.53 trillion to the United States economy.³

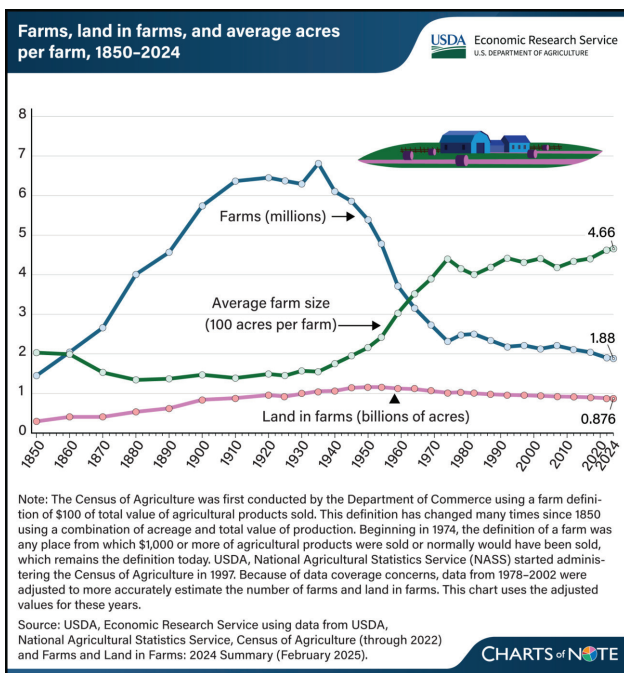


Figure 2: Declining number of farms in the United States.⁴ The declining number of U.S. farms indicates the operational pressure facing the agriculture sector.

The United States has approximately 1.88 million farms, and in 2021, an estimated 87% of businesses in the U.S. agriculture industry utilized AI in some capacity.^{4,5} However, due to the cost barrier, many smaller farms are unable or unwilling to invest in this technology, as supported by Figure 3, which is also reflected in Boston’s statement, “Despite the promise of digital tools and autonomous machines, cost is a big barrier”.⁶ All of this data demonstrates that the market is largest for medium to large farms, which is why the research will primarily focus on these farms.

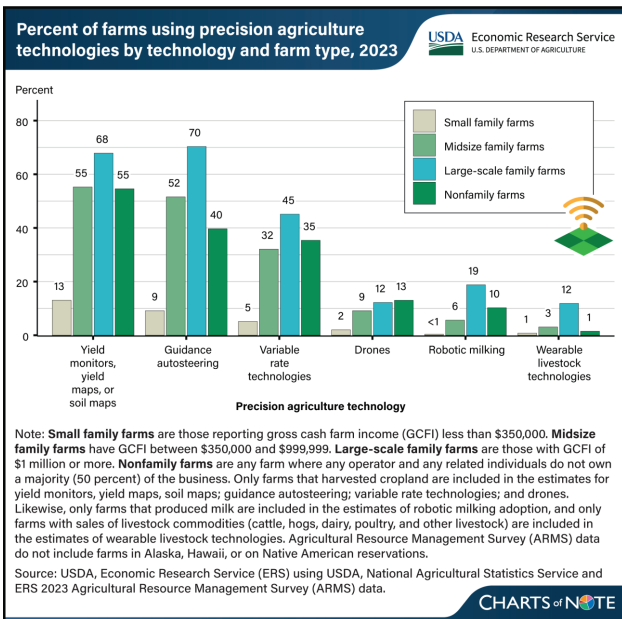
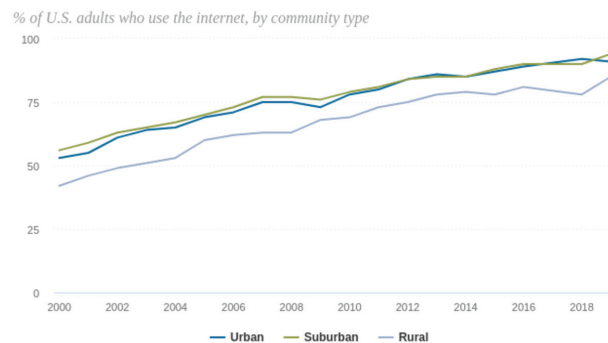


Figure 3: Percentage of each size of farm using different precision agriculture technologies.⁷ The data demonstrates the increased use of precision agriculture in larger farms, illustrating that medium to large farms represent the most viable target market.

This entire market is relatively new and is underserved by hyperscalers in the United States, which means there is room for startups.⁸ Part of the reason for it being underserved is that it is a relatively new market, and it is a business that requires high initial investment costs and skilled employees.^{9,10} Furthermore, because edge networks process data, there are regulations on the privacy and security of the data. Across the nation, several regulations govern data storage, which can create difficulties and additional expenses. These guidelines are significant enough that, in 2024, 68% of edge deployments faced challenges adapting to these laws.¹¹ Additionally, California has a law regarding the transparency of data, known as the California Consumer Privacy Act, which should be taken into account when examining location.¹¹ Despite this, many businesses continue to strive to solve latency issues.

Several problems have contributed to the lack of latency solutions in rural areas of the United States, including high initial investment costs, skill shortages, and the historical struggle of the rural regions with broadband connectivity. Rural areas in the United States have lagged in the adoption of broadband connectivity, as revealed in Figure 4, which is a problem because edge networks often require strong connectivity.⁹ However, the graph also demonstrates how rural areas are catching up to urban areas, which is an important observation, as this could be a contributing factor to the growth in technology in rural areas.

Internet use by community type



Source: Surveys conducted 2000-2019. Data for each year based on a pooled analysis of all surveys conducted during that year.

Figure 4: Rural and urban broadband usage percentages.¹² The gap between rural and urban broadband adoption highlights a key issue, but the narrowing gap highlights improved infrastructure conditions that could support wider deployment of edge computing solutions in rural regions.

Latency creates issues such as processing delays, slow data upload speeds, data loss, and slow responses.¹³ Furthermore, these problems are demonstrated in Table 1, which reveals the impact of different sources of latency. Ultimately, latency is a crucial issue that hinders further enhancement of the technology’s efficiency.

Table 1: Negative impacts of latency on farming technology.¹⁴ Latency leads to delayed processing, data loss, and inefficient system responses.

Latency Source	Description	Impact on Agriculture
Network Propagation Delay	Time taken for data to travel from sensors to cloud servers	Delayed analysis and slow system feedback
Cloud Processing Delay	Time consumed in cloud-side data processing and decision-making	Sluggish response in automated irrigation or spraying
Data Congestion and Queuing	Data packet delays caused by bandwidth limits and overload	Inconsistent monitoring results
Sensor/Device Processing Limitations	Latency introduced due to low-power sensor capabilities	Reduced sampling rates and system reactivity
Actuator Activation Delay	Time taken to convert processed data into physical action (e.g., irrigation)	Missed intervention window in crop lifecycle

Medium to large farms that utilize technology are likely to pay a high price to reduce latency, as this will enable them to improve the efficiency of their machines. Building edge networks on these farms will enable data computation closer to the machines, resulting in benefits such as improved crop yields and reduced energy consumption.

Methods

Primary Research:

The research employed a mixed-methods approach. The interviewees were four individuals with experience in either or both the agricultural and AI industries. The demographics of these individuals, including age and location, varied and were not taken into account beyond the fact that they lived in the United States. The interviews, which lasted between 20 and 30 minutes each, were conducted over video calls. All interviewees gave their consent for the use of the data. The interview questions are presented in Table 2 and varied according to the background of each interviewee. Additionally, the interviewee with experience in both areas was more of a discussion, which is why there is no list of questions for them.

The sampling technique used was snowballing, as it could help gather as many connections as possible for the interviews. Many individuals with experience in the agriculture, AI, and real estate industries were contacted. Additionally, authors of articles related to the topic were contacted. Interviews presented a significant challenge in this process due to a lack of connections and difficulties in obtaining responses to interview requests.

Table 2: Interview questions asked for each interviewee.

Interview Questions for Primary Data		
Interviewee 1 (Experienced in both agriculture and AI)	Interviewee 2 (Experienced in agriculture)	Interviewees 3 and 4 (Experienced in AI and data)
This interview was more like a discussion, so there are no specific interview questions to address.	<p>Could you tell me about your experiences with AI so far?</p> <p>Do you use any AI tools within your business that help make things more efficient? If so, could you tell me about them?</p> <p>What are the biggest pain points that you have noticed with AI technology?</p> <p>Has latency shown up as an issue for you at all or have you heard about others struggling with it?</p> <p>In what ways have you noticed people coming up with solutions for these problems with AI? In what ways have these solutions fallen short?</p> <p>What are the biggest factors for you when looking at new technology?</p> <p>Are there any other things that you believe are important that you would like to share with me?</p> <p>Is there anybody else that you think I should talk to?</p>	<p>I saw you worked in _____ industry. Are there any other experiences you have had with startups that don't get off the ground related to AI technology?</p> <p>I saw you worked at _____ do you have any specific experiences with this company working with evolving technology?</p> <p>How have you experienced or seen new technology incorporated into businesses over the last 5 years?</p> <p>What industry do you have experience in? Could you tell me more about how it has shown up differently in different industries?</p> <p>Do you have any experience with new tech or AI in less developed areas or remote areas?</p> <p>How have you had any struggles while trying to develop and/or implement new technology? Have you had any experience with trying to sell new types of tech in less developed areas?</p> <p>Have you experienced latency using these new developed technologies? And if so how?</p> <p>When you're considering new technology to develop to increase efficiency, what are the most important factors for you in decision making?</p> <p>Are there any other things that you believe are important that you would like to share with me?</p> <p>Is there anybody else that you think I should talk to?</p>

Secondary Research:

There were many research questions aimed at providing an understanding of the background information, the problem, the competitors, the market, and the business opportunity. The quantitative data primarily consisted of statistics regarding the number of individuals who required the service and the edge computation market. The qualitative data consisted of the need, solution, and competition. Throughout this research, various sources were utilized, including academic journals, articles, blogs, data reports, case studies, fact sheets, and market reports. The main challenge was finding case studies and market reports that were specifically related to the topic, which was likely due to the relatively new market, as few people had yet released detailed market reports and case studies.

Results

Primary Research:

The interview process revealed a lot of new information, presented in Table 3. For instance, during the interviewing process, the interviewees indicated that latency is a problem that may affect a smaller group than initially hypothesized. For example, when interviewee 3 stated, "For the stuff about soil irrigation, to me it seems like latency won't be that serious." It was hypothesized that all farmers who used technology would experience this need, although the farmer interviewed did not perceive this as a problem, and two of the people involved in AI thought it was most likely not a problem for most farms, as they believed the technology is designed to operate on low connectivity.

However, there was one outlier who believed that this latency issue was a significant problem in the industry. The outlier discussed how, as agriculture has begun to require data, it has created an enormous demand, which is why many businesses have shifted their focus to meet this need. A potential reason this person differed was that they had extensive experience specifically in the agriculture and AI software technology industry, and remained highly involved, maintaining numerous connections within it. It is essential to analyze this, as it reveals a more specific market and identifies who, if given more time, should be interviewed to obtain the best analysis of the problem and market.

Table 3: Key findings from each interview. The findings reveal differing perspectives on the severity of latency, with a majority suggesting that latency has minimal impact on agricultural technology.

	Key findings
Interviewee 1 (Experienced in both AI and agriculture)	The believed issue is very apparent in the industry currently. A few years ago, the industry lacked sufficient funding; however, with the emergence of new technology, a vast market has now opened up.
Interviewee 2 (Retired vineyard farmer experienced in agriculture)	They utilize technology such as weather forecasting, drone flyovers, and soil sensors. Much of this technology must be tailored to farms, as it will otherwise cause problems. The technology typically works well, and the only significant issue is the cost.
Interviewee 3 (Experienced in data and AI usage)	The technology that requires data is likely built to function on low connectivity, so low latency is likely not very vital. However, healthcare is something they believe could have much more potential, as it requires sending a large amount of notes and information back and forth, typically through the cloud.
Interviewee 4 (Experienced in AI tools and programming)	Implementing AI into production often presents numerous challenges. Typically, low latency is not necessary for sending small amounts of information and is only required when operating complex websites or applications.

Secondary Research:

Market Analysis:

The primary focus of the market is the edge computing industry. The market size in 2024 was \$23.65 billion, and it was expected to grow at a compound annual growth rate (CAGR) of 33% from 2025 to 2033, reaching \$327.9 billion by 2033.¹⁵ The market size data and projected growth can be further highlighted in Figure 5. The market share is illustrated in Figure 6, which reveals that large enterprises owned the majority of the market. Additionally, North America had the largest market share and, in 2024, accounted for the largest revenue share, at 38%, with the U.S. leading the region.¹⁵ Figure 7 further demonstrates North America as the market leader.

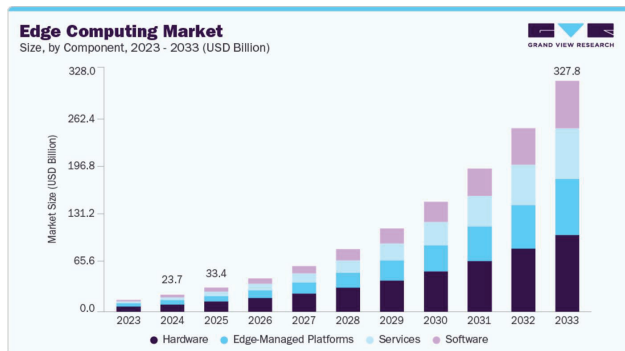


Figure 5: Market size of edge computing.¹⁵ The rapid projected growth of the edge computing market demonstrates long-term viability and promising industry growth.

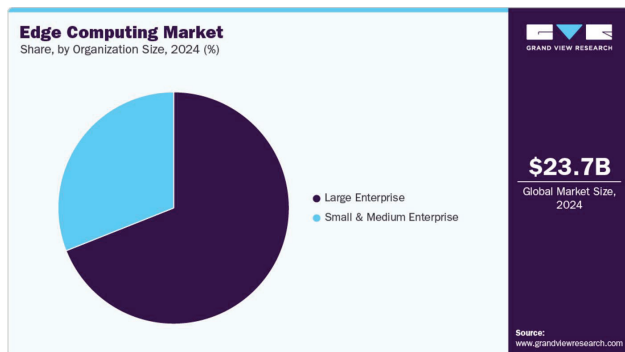


Figure 6: Edge computing market share by organization.¹⁵ The dominance of large enterprises suggests there is tough competition. However, this also implies room for a specialized, niche business to break into the market.

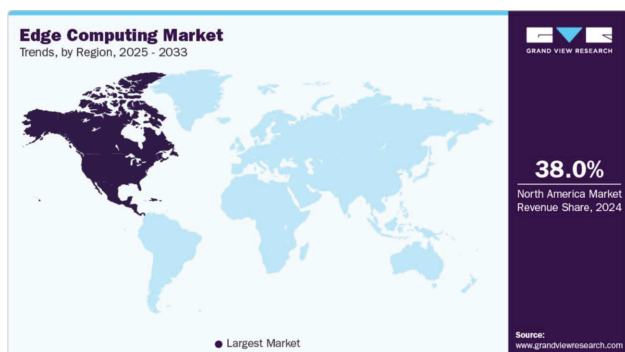


Figure 7: Leader in edge computing market revenue.¹⁵ North America's leading revenue highlights this region's strong adoption of edge technology, which supports focusing on this region as a business.

Moreover, this service requires five main skills: programming, networking, infrastructure, platforms, and security.¹⁶ Furthermore, the technology used in edge networks is sourced from numerous major suppliers, including IBM, Taiwan Semiconductor Manufacturing Company, Cisco Systems, Intel, and several other prominent companies.¹⁷ Several pricing strategies were available for this service. Most services employ a monthly billing pricing strategy, which takes into account factors such as usage, the number of devices, and the amount of data.¹⁸

Case Studies:

Two types of case studies were identified during the research process. The first case study illustrated how latency presents issues, while the second revealed the potential of technology when not hindered by latency.

The first case study followed a tree and crop farm located in a remote area of India. Due to the unpredictable weather at the farm, farmers resorted to using AI-based weather tracking apps to predict rainfall levels in their specific location. The farm eventually reverted to its original methods of weather prediction due to issues with accuracy, which were caused by a lack of connectivity and inadequate technological infrastructure.¹⁹

The second case study tracked three different farms that had implemented latency-aware technology. One took place in a vineyard in Tuscany. They implemented a hybrid system using both edge and cloud systems to automate irrigation. Ultimately, this led to a 22% reduction in water usage, accompanied by a 12% increase in grape yield. The second was an intelligent irrigation system in the rice fields of Andhra Pradesh. They implemented latency-aware fog nodes that tracked soil moisture, which resulted in a 30% increase in energy efficiency and improved soil moisture stability. Finally, in the Netherlands, a 5G IoT system was implemented, enabling real-time decisions about temperature. The result was a crop optimization for tomatoes and lettuce.¹⁴

Competitive Analysis:

This competitive analysis examined a potential direct competitor and a similar company that had failed. The purpose of this competitive analysis is to investigate what potential competitors did right and what they did wrong, to learn from them. Similarly, it is just as essential to examine failed companies to avoid the mistakes they made.

A potential direct competitor is Trilogy Networks, a company that offers several services tailored to the agriculture industry, including software, edge computing systems, and technology that helps automate farms.²⁰ Table 4 displays the comparison between this potential business and Trilogy. Trilogy is a company that benefits from its longevity, but the main difference between the hypothesized business is that it focuses solely on providing edge computing as a comprehensive service. Trilogy offers a variety of products, which can be confusing to potential customers. Focusing on a specific service allows this potential business to become an expert in one area, rather than trying to cover multiple different services.

The other company researched was EdgeMicro, a company that launched in 2017 but later went into liquidation in 2021.²¹

They deployed modular data centers on the client's site. Unfortunately, the reason for their failure is not publicly available; they stopped updating their site, removed their LinkedIn page, and executives declined to answer questions.²¹ However, some possible reasons could have been financial issues, competition, or their business model.

Table 4: Key findings from each interview. The comparison reveals that while Trilogy Networks offers diversified services, there is an opportunity for a specialized business.

	Product	People	Place	Promotion
The proposed business	Providing latency-reducing edge networks to medium to large farms.	A large number of highly skilled individuals who understand data infrastructure, employees skilled enough to manage the technology, and teams to help the company function effectively.	The product will be installed on medium to large farms, and will be a physical building that stores the data.	Offer the ability for farms to request the service in their areas, which would be through word of mouth and customer prospecting
Trilogy (potential competitor)	Using telecommunications, cloud infrastructure, and AI expertise to solve problems for farmers. ²²	The individuals involved in this business process are not described.	Targets areas with strong agriculture and infrastructure, and operates both digitally and through physical infrastructure development. ²³	They sell the product through their website, where customers contact them. They market through industry events such as "Trilogy at The Desert Difference: FarmTech Connect" and their results. ²⁴
EdgeMicro (Failed startup)	They sold custom-fitted micro data centers in flexible locations. Their expertise was in building fast, modular data centers in as little as 8 weeks for more modular data centers. ⁵	The people required to provide this service are not described.	The location for this service varied, as it was intended to be used anywhere, and these physical buildings stored data. ⁶	Their promotion tactics are not described.

Discussion

Reflecting on the research collected enables a more straightforward interpretation of the data and minimizes any possible biases that may be present. Additionally, it is important to interpret research that opposes the original hypothesis to inform the development of an improved business statement.

Assessing The Data Collection:

An area of potential bias is the interviews; the group was predominantly composed of individuals from the AI industry, with only one farmer included. Similarly, there is a possibility of confirmation bias, as specific research can be included or excluded.

Reasons for challenges with interviews included a lack of connections due to the industry's niche nature; this challenge varies depending on the researcher conducting the study, and can render the data less accurate, since the quality of candidates varies.

More time and resources would have allowed for a larger group of interviews, providing a better understanding of the target customers and identifying the most ideal interview candidates. Furthermore, allocating more time and resources would enable the improved collection of secondary data. During the research, no free case studies analyzing potential business competitors were found; therefore, the competitive analysis utilized information gathered from competitors' websites and related articles. Additionally, the market reports were all expensive, so the market research used the free sample portions from the market reports.

Refined Business Model:

It was initially hypothesized that medium to large farms in the United States are likely to pay monthly for a service that delivers latency-reducing edge networks directly on the farm

sites. Although this belief was essentially correct, the perceived customers differed from what was hypothesized.

Multiple interviewees describe edge networks as being capable of reducing the latency of technologies in several industries, such as healthcare and agriculture. This is supported by the latency-aware technologies case study that effectively illustrates the benefit of reduced latency in technology.¹⁷ While the solution's efficacy is clearly demonstrated, the market opportunity is not as clear. Interviewee 1 explained that there is a market opportunity, and the case study on the farm in India explicitly shows the market for this issue.¹³ However, the other interviewees convey that this market is not very apparent, if apparent at all. There is a clear contradiction about the market for this problem, and it is important to factor in all viewpoints and experiences. Interviewee 1 is most experienced in this market, and the others are not as integrated in both agriculture and technology. Given interviewee 1's increased experience, which is reinforced by case studies, the market is likely apparent; the other interviewees have suggested the size of potential customers may be less than hypothesized. The perceived customer could be farms that utilize a lot of the technology, as the interviewees believed that the technology was designed to operate on low latency. However, when a significant portion of the technology relies on data, latency can cause problems, which may make the market slightly more niche than initially hypothesized. Nevertheless, it remains a business-to-business (B2B) model, as the service is being provided to farms, which are considered businesses.

The supplier and individuals involved are a potential barrier. While the suppliers, who are major brands including Intel, IBM, and Cisco Systems, are essential for their innovations within the industry, they also create problems related to competition and market dominance.⁸ Similarly, the skills required for this industry, including programming, networking, infrastructure, platforms, and security, pose a significant challenge.¹⁰ Not only must the individuals be highly skilled, but they must be willing to work at a job that requires them to live or travel consistently to rural areas.

The competitive analysis of Trilogy Networks has demonstrated that the most effective way to sell the service is through e-commerce.⁴ E-commerce enables businesses to reach potential customers nationwide, which is particularly crucial for niche markets. The best market to provide this service is rural America, since the United States holds the leading market share in the edge computing market.¹ Additionally, many data localization laws require data to remain within the country, creating challenges when operating across multiple borders, making it easier to serve just one country.² Finally, within the United States, rural areas present a lucrative market opportunity because they are untapped by the larger hyperscalers, which are big technology enterprises. Interviewee 1 describes how hyperscalers are focused on building data centers within proximity to cities for increased quantity of potential customers, because they perceive more customers as lower risk, which is further supported by secondary research.¹²

The majority of interviewees revealed that the possibilities for promotions are limited due to this industry's niche mar-

ket. Because of this, marketing that involves direct contact with potential customers, such as prospecting or participating in events, is the most effective. Trilogy Networks markets itself in this manner, participating in events such as “Trilogy at The Desert Difference: FarmTech Connect”, as highlighted through competitive analysis.⁴ While this product does not typically require traditional branding, there are specific ways to create a more compelling service for the customer, such as creating a seamless and easy transition for new customers. This is exposed by Interviewee 2 as they describe that technologies often don’t function properly or are very difficult to implement.

Multiple articles reveal that a significant challenge in providing this service is the high initial investment cost.¹⁰⁻¹⁹ The only ways to make it more affordable for the business are to find ways to limit on-site management, including getting a digital management system, investing in quality technology, and keeping marketing costs down. An article discussed various pricing models, and one that appeared frequently was the monthly payment model.²² One way to price the service is to charge a varying monthly payment. The monthly payments are based on factors such as the number of machines using the service or the amount of energy consumed. Once the cost of installing the service is paid off and a profit is made, the monthly cost decreases to incentivize customers to continue paying for the subscription. This type of model would also increase affordability, since customers do not have to pay all at once. The risk of this subscription model is that farmers remain liable for payments even if they can no longer afford the subscription.

■ Conclusion

The target market for latency-reducing edge networks is medium to large farms in the United States, with marketing efforts focused on e-commerce and customer prospecting. The cost is a monthly fee that the customer is contractually obligated to pay until the cost is covered and a profit is made; the price will then decrease, incentivizing continued payment. The benefit is increased crop yields and reduced material waste. Customers can request an inspection to help determine affordability and accessibility, as they vary.

Recommended next steps for evaluating this business opportunity include more extensive market research to validate the efficacy of this business model, including more interviews with experts in AI and agriculture, and potential customers. Additionally, more research should be done on the economic model, including start-up costs, pricing strategy, and profitability.

This business opportunity has the possibility to extend beyond solely agriculture. It can translate for industries ranging from self-driving cars to healthcare, because all of them are experiencing latency in less developed areas. Interviewee 3 brought up healthcare, and the original plan for the research was to research both healthcare and agriculture. Nonetheless, the opportunities for this business to expand into all industries are tremendous. The purpose of this business is to contribute to a future where food insecurity is no longer a problem.

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