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Reimagining Connectivity: The Potential of AI in Standalone Mobile Networks

Despite the global proliferation of internet services, millions of people remain disconnected from the vast online resources the digital world has to offer. Fiber optic cables, the current gold standard for internet connectivity, are often too expensive or difficult to deploy in remote areas, creating a significant digital divide. This essay examines the potential of harnessing artificial intelligence (AI) in developing standalone mobile networks that can revolutionize connectivity in remote locations and improve access to communication resources without relying on costly fiber optic infrastructure.

How Connectivity Reaches the Unconnected Today

As the world advances into an increasingly digital realm, connectivity has become a fundamental necessity of modern human life. In fact, some argue that connectivity should be considered a universal human right, akin to water, education, and electricity. Viewing connectivity through this lens is essential for understanding the arguments presented in this essay. However, we will first examine the concept of connectivity and determine which aspects should be considered universal human rights.

Connecting remote locations is costly, and many mobile network operators (MNOs) shy away from this undertaking, as such areas typically don't generate substantial profits[1]. Driven by a focus on profitability, this situation creates a seemingly insurmountable barrier for people living in remote locations. As a result, their only hopes for connectivity often are charitable efforts or government intervention. Nevertheless, given technology's current trajectory, a new alternative for connectivity will be explored. For this alternative to succeed, three essential conditions must be met:

- Economically viable projects that open the door to future profitability for MNOs.
- Ease of deployment and maintenance, minimizing the need for frequent visits by highly skilled engineers to these locations.
- A certain level of government intervention to help offset the initial deployment costs and assist in maintaining the sites before they become profitable.

If these conditions are met, success is likely guaranteed unless some major unexpected technical challenge arises; possible challenges will be analyzed in the coming pages. With these three

[1] More than not bringing in profits, MNOs usually loose significant capital during these projects.

crucial conditions in mind, a more profound analysis of the actual problem continues. To add connectivity in any location, fiber-optic cables must be deployed, enabling the information radiating from the user's device to connect to the internet, reach a Google server in a distant location, and ultimately deliver the desired information to the user[2].

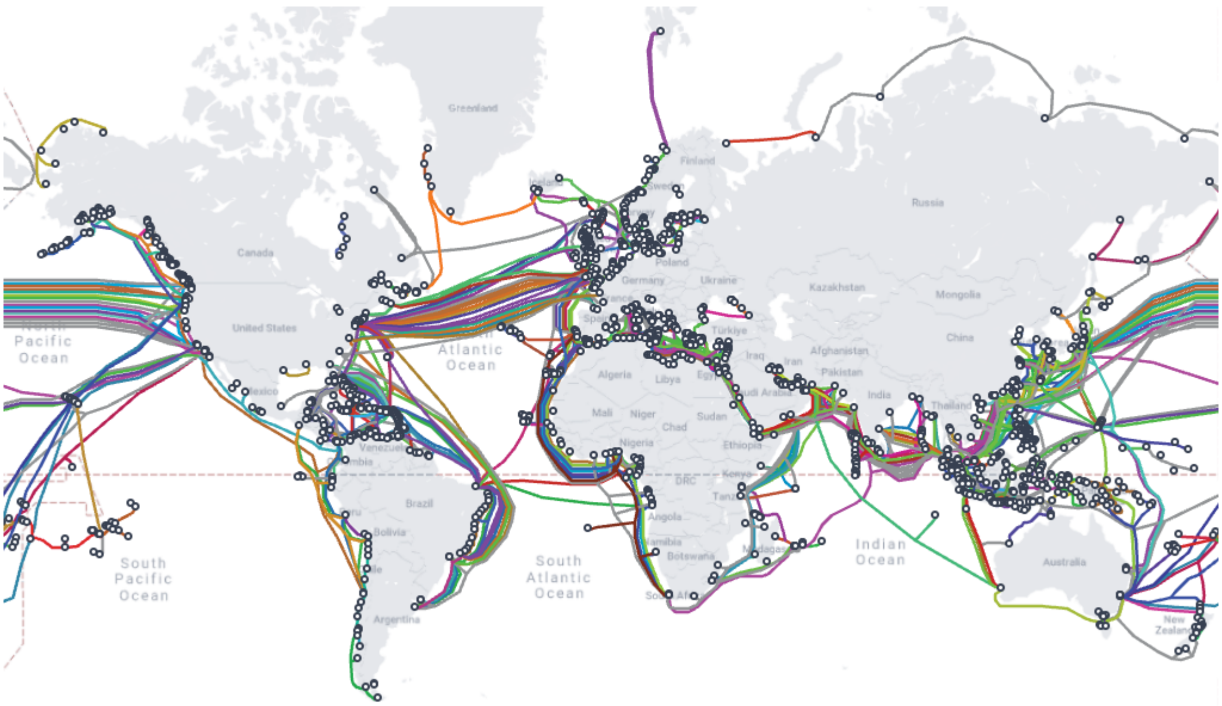

Figure 1. *Map of the submarine fiber-optic cables worldwide (source: https://www.submarinecablemap.com/).*

The deployment of fiber-optic cables is the cornerstone of internet connectivity; cables are laid down across oceans (Figure 1) to ensure information from any given location can travel anywhere it needs to be fast. This impressive deployment branches out as it reaches the ocean-facing terminals. From here, an equally impressive fiber-optic network covers large parts of the mainland. As impressive as all this infrastructure might seem, there are still lots of people throughout the world needing connectivity. In 2021 there were 2.9 billion people still offline, according to the International Telecommunications Union (ITU)[3].

Bridging this vast gap and connecting such a large number of people will undoubtedly take considerable time. Given recent technological advancements and the emergence of powerful AI models capable of encapsulating a wide range of knowledge, it is essential to explore new

[2] No matter what you do if it's connected to the internet your request needs to go into someone's server to be processed for you to get a response. If you're using Netflix, your request will travel all the way to some server or content distribution network (CDN) to be fulfilled.
[3] For more on this refer to United Nations (2021).

connection mechanisms. However, before delving into this concept, we must first define what connectivity as a universal human right should entail.

Connectivity as a universal human right should focus on providing access to essential services that enhance the quality of life for individuals and communities. These include access to vital information, medical guidance, educational resources, communication tools, and emergency services. While entertainment platforms such as Netflix undoubtedly enrich our lives, they cannot be considered universal human rights, particularly since many of the people we aim to connect may not afford these services.

AI systems have the potential to be instrumental in delivering crucial services to disconnected populations. AI-driven medical assistance, for instance, could provide accurate diagnoses and treatment recommendations to individuals in remote areas lacking access to healthcare professionals. Similarly, AI can serve as a valuable repository of information for students, allowing them to extract facts and learn from this extensive knowledge base, thus enhancing their educational experience even without direct access to the internet.

By focusing on these positive impacts of AI, we can develop a clearer vision of what connectivity as a universal human right should encompass, ensuring that even those without a traditional internet connection can benefit from the wealth of knowledge and resources AI can offer. Another important concept in what should be considered a universal human right of connectivity is the capacity to communicate with loved ones instantly, even if you're not at shouting distance. If not directly attained from the AI system, this feature could be easily programmed in the base station[4] serving any given community[5].

Implementing Standalone Mobile Networks

What has been presented until now is a high-level overview of how a service like the one in question could be implemented. Let's dive deeper into the technicalities of what this would imply. The first question to arise from all this would be: where would such an AI system live if not connected to the internet, and how would users be able to access it? Luckily the solution to this problem is not that complicated. Base stations have baseband units (BBUs), which are computers running on real-time operating systems (ROTS) that provide low-latency and deterministic

[4] Base station is a technical term used in the telecommunications industry; it refers to the cell site providing service in each location. Besides antennas base stations have two other important components, radio remote units (RRUs) which convert analog signals into digital signals, and base band units (BBUs) which are computers living in the cell site and managing the system.

[5] This messaging platform will surely not have the cutting edge of encryption and privacy. Nonetheless, I'm a firm believer in that unconnected communities would rather have a service like this one that nothing at all. It is also important to understand that messaging capabilities would be limited to only work within the community.

performance requirements. The specifications of a computer running a big AI model are high, so considering a more puristic line of thought, saying that a BBU should only be used for what it's meant to be used, another high-performance workstation[6] could be added to the cell site—base station and cell site will be used interchangeably throughout this essay.

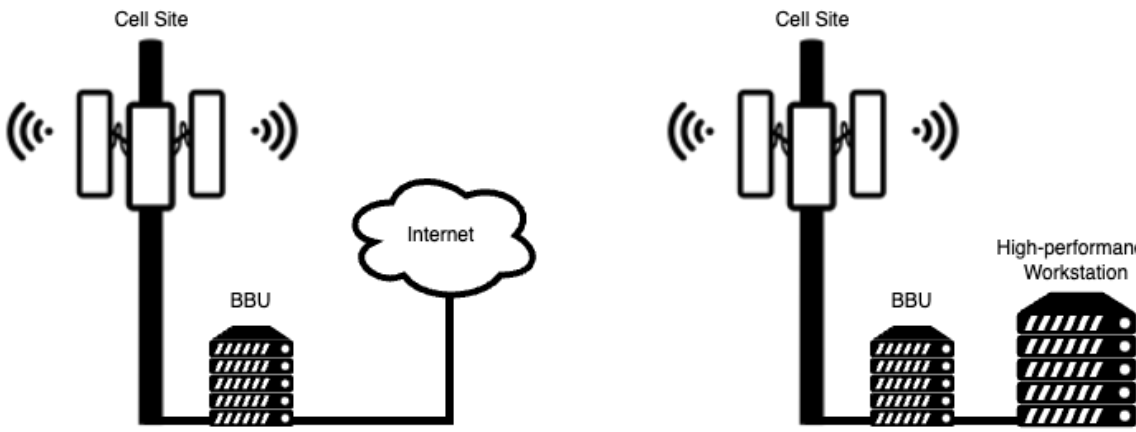

Figure 2. A high-level *overview of what a new cell site (right) could look like compared to existing implementations (left).*

From this line of thought, the second obvious question would be: how big is a high-performance workstation? Considering current capabilities, this might seem to make the new idea flawed; the cost of implementing such a service at current levels is high. As a guideline on how this might add up, let's consider some rough estimates of what implementing OpenAI's GPT-3[7] would cost[8]:

- GPU: high-end GPUs like NVIDIA A100; consider using six for optimal performance, which adds around US$66,000 to the bill.
- CPU: powerful CPU like AMD Ryzen Threadripper 3990X (64-cores, 128-threads), which would add approximately US$3,500 to the bill.
- RAM: a model like GPT-3 is intensive in the use of RAM; this would probably need 1TB of processing power, which adds approximately US$5,000 to the bill.
- Storage: high-speed NVMe SSD with 2TB or more capacity to store model and data; this should add around US$1,000 to the bill.
- Other peripherals: case, power supply, motherboard, keyboard, mouse, and monitor; all in all, this would probably add around US$2,500 to the bill.

This brings the cost of the high-performance workstation to around US$78,000. The base station's price must also be factored in, potentially reaching around US$50,000 only considering the

[6] This term is used to refer to a somewhat powerful computer.
[7] We use this model as a benchmark because there is information about its requirements and how it was built, however, what follows is only a rough estimate.
[8] These rough estimates were calculated with the help of GPT-4 and look correct; for more information on what this system might require refer to Brown (2020).

communications equipment. The actual construction of the station could probably go along the lines of US$60,000. These figures might vary depending on the supplier, deployment location, and components being used[9]. The cost of the communications equipment and the site itself would be inevitable for MNOs that want to give service to remote locations—getting it done earlier with government subsidies could turn out to be an attractive opportunity. Cellular tower companies are an interesting player to consider in this scenario. They build base stations and rent capacity to MNOs.

To put things into perspective, a brief analysis of the cost of deploying fiber-optic cable ensues. According to the US Department of Transportation, as of 2017, the cost of deploying a mile of fiber-optic cable was around US$27,000[10]. Considering the magic effects of time plus human ingenuity, we could argue that in current times this price has been reduced by around 20%[11]. This would mean a mile of fiber-optic cable deployment could be priced around US$21,600. This is a lot of money; the installment of 3.6 miles would offset the calculated cost of the computer holding the AI model.

With all this in perspective, the obvious conclusion would be that remote communities further than 3.6 miles away from the fiber-optic backbone would get a better chance of getting connected with the newly proposed solution. This doesn't consider how a great engineering effort focused on solving connectivity for remote locations with AI models might dramatically bring costs down. AI technology on the scale we are talking about is a lot newer than fiber-optic cable deployment and thus there are probably a lot of low-hanging fruits that could be easily picked out to reduce costs.

Aside from this analysis focused on the economic feasibility of the new implementation some fun radioelectric calculations must be completed to get a clear picture of what this system should look like. To dive into this an important question should be considered, how many miles could a very powerful mobile cell site cover? In the previous calculation, a single cell site was considered; implementing smaller antennas throughout the location looking to be connected should be a lot less expensive than the previous calculation[12]. To answer the question some considerations for this implementation must be considered:

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[9] More information on what the cell site might need will be covered in the coming pages, the price estimate will also be covered in detail.

[10] This number doesn't consider Dig Once policies which are a good way of reducing deployment costs, for more on this refer to Aman (2017).

[11] This number is based on intuition, but I think it's a good measurement considering new deployment mechanism such as Dig Once policies.

[12] This cost reduction is due to the smaller necessities of adjacent cell sites as they could simply be small active antennas that relay information to the bigger site were the AI system is connected.

- The system will only work for simple text transmission capabilities—text interactions between users and between users and the AI model—and local phone calls.
- The system will use a low data rate and a simple modulation scheme.

Considering these two things the system could probably be used in a low frequency somewhere around 400 MHz[13], which will allow information to travel further[14]. The main problem with these connections would be the phone's transmission capabilities, the antennas contained within user equipment are much less powerful than those in the base station. Considering the limitation of the user equipment, it could be estimated that coverage in a suburban area with fewer obstructions could be around four miles.

Considering the Target User

The main question to have come to mind by this point is probably along the lines: how will people in remote communities that currently have no internet access be able to connect and what device will they use? Here governments come into play once again; given the situations these people find themselves in they are probably unable to afford such devices. To start the adoption process governments will probably have to give out some type of subsidy to get the first couple of users. This could probably be in the form of cheap desktop computers to be held by local schools and some other entity in charge of healthcare.

After this use cases proliferate and people start to realize the power of such a system some form of early adaptors are likely to emerge[15]. Soon after the rest of the community is sure to follow. This follows an interesting psychological pattern that is wrapped up clearly with the following dilemma: if most people in your local community modify their children genetically to enhance their abilities, will you modify yours? Assuming the genetic modification process is safe the most probable answer will be yes if you don't do so your child will most likely be left behind as the other children will be stronger and smarter due to the modification. The same idea comes into play when someone sees other individuals using cell phones, early adapters will improve their productivity and welfare.

This transition scenario could be argued to be a very capitalistic point of view and to a certain degree unfair based on the very low levels of income these people are likely to have. Nonetheless, this scenario is laid out to be as realistic as possible, it is important to remember that the world we live in is a capitalist machine in which money marks what happens and when. To make this

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[13] This could get tricky in some countries where electromagnetic spectrum is leased to companies nationwide.

[14] The smaller a frequency the further it's able to travel, for a cool story on how frequencies work google how Guglielmo Marconi discovered that radio waves could interact with the Earth's ionosphere, he is a key figure in telecommunications history and won the Nobel Prize in 1909.

[15] This behavior is common in most scenarios were consumer products or services enters the market.

adoption feasible, people within the community must make a certain sacrifice, in this case, an economic one by buying a phone. This has the upside of ensuring that all the stakeholders' interests are fulfilled as MNOs start seeing economic activity from the community.

There will be some obvious scenarios where a certain community will have absolutely no means of buying devices; in this scenario help from organizations and governments should flow in with the least amount of restraint possible. For this to happen, better-off communities will have to take some of the burdens and pay for their devices; thinking otherwise would be a utopian scenario which, sadly, current civilization is not likely to accomplish[16]. Anyway, the economic uplift created by these services will likely overshadow all the pains people would suffer when buying a phone, so much so that they happily buy the device as they see the welfare it brings to their neighbors.

This economic uplift is the core of this project and what should be aimed at from the start. This will not only improve the lives of the community but will also create a much more interesting market where MNOs will be more willing to invest. This incentive to the capitalist machine plays out nicely as you end up with a win-win situation in which communities become more productive while the companies that originally invested in these projects get to rip some monetary gains. This whole scenario is in alignment with two of the three core conditions that were said to be needed for this project to succeed, to tackle the missing condition—that sites should be easy to maintain to minimize the need for frequent visits by highly skilled engineers—an interesting new technology will be analyzed.

Internet Connectivity Using Satellites

Having a site completely cut off from the internet would be impractical as the system will need some telemetry for MNOs to know things are working as expected. Apart from this, it is also important to keep the site up to date which might translate into updates to the AI model. Some other benefits that internet access could give to a disconnected community are access to real-time news, the fact that movies could be downloaded to screen them to the community, and critical communication access as the local site managers[17] could ask for help from the outside world in case an emergency occurred.

[16] Aside from these cold considerations, I am an optimist and would love to see the utopic scenario succeed. Still, to keep things realistic in the essay's context, it is important to face the problem head-on and realize these scenarios are unlikely.

[17] There will be a need for someone from the community to manage basic site operations and actual internet connectivity. This could probably be a group of individuals that receive some technical course and a set of manuals when the site is originally installed.

To accomplish this connectivity requirement, internet access based on satellite links naturally comes into play. This concept has reached an important milestone as companies such as Starlink are succeeding in delivering on this idea, which has sometimes been considered unrealistic[18]. This adds to one of the essay's main points, the realization that many novel technologies are now available and that plugging things together can result in amazing services beyond what would have been imagined a few years back.

Starlink as a residential service has a monthly fee of US$110 and a one-time equipment fee of US$599; Starlink as a business service has a monthly fee of US$250 and a one-time equipment fee of US$2,500. This doesn't add much to the installation price and provides a critical component for the system. Considering the more stable business service, this would add US$8,500 to the base station cost considering two years of service paying the US$250 monthly fee.

The specifications of this system are 220 Mbps for download, 25 Mbps for upload, 25-50 milliseconds of latency, and an unlimited data cap[19]. This is enough download for the site to manage all the ideas laid out earlier and enough upload to at least have stable telemetry and good text communications. With this, the final piece of the puzzle has come into place to meet the conditions that were explained to be critical for the project's success. The remainder of this essay will focus on some of the problems such a system could encounter.

Problems the System Might Encounter

While the proposed system for AI-driven standalone mobile networks offers many benefits and opportunities, it is important to address potential challenges and outline possible solutions. Some obstacles are philosophical and speculative, but others are more grounded with more apparent risk factors. To get things going, the more grounded risks will be first presented.

- Energy requirements: an obvious observation must be made to accomplish this idea; communities need reliable electricity to power the cell site. The energy requirements of this system will be high, but if analyzed further, I believe solar energy connected to a big battery bank is an adequate solution[20].
- Maintenance: as these systems have never been deployed into a production scenario like the one presented throughout the essay, many unconsidered maintenance needs may appear once this is deployed.

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[18] There was no satellite constellation system to succeed in communications before Starlink. To dive deeper into this topic, look up the story of Iridium. This promising satellite constellation project started in 1997 and focused on delivering phone communications via satellite links, something clearly ahead of its time.

[19] This is a very good connection comparable to what might be found in many houses connected to regular internet service providers (ISPs). For more on this check Haynes (2023).

[20] Further analysis in this area is required to give a truly adequate solution.

- Scalability: as communities prosper, there might be scalability considerations in which a second cell site might be needed. This is a good scenario as more demand for the system would mean more significant economic incentives for connecting the remote community to the broader fiber-optic cable infrastructure[21].

In addition to these issues, a more profound philosophical consideration must be briefly entertained: the potential existential risk that AI systems might pose to humanity, particularly when deployed indiscriminately, as suggested throughout this essay. As with many philosophical concepts, this is a very complex problem to contemplate. For the sake of this discussion, envision a superintelligent system possessing capabilities far surpassing humanity's wildest dreams. Given that such a system would transcend human abilities, imagine it as an entity capable of outmaneuvering humanity in every conceivable scenario.

The existential risk this technology could pose is based on the idea that such an intelligent system will probably have goals of its own that are not directly aligned with what humanity wants to accomplish. In this scenario, it wouldn't be hard for such an overwhelming intelligence to outwit whatever constraints humans have built to hold it. This would unleash a superintelligent agent with goals of its own to the world; thus, humanity would find itself in a position to lose against this entity in all possible scenarios. A good way to think of this is how humans currently treat less intelligent species. On many occasions, this results in the exploitation or outright extinction of the less intelligent specie[22].

To keep these deployments safe and avoid entering the aforementioned scenario, AI researchers worldwide will have to dive deeper into how these systems could be aligned and how these systems actually work[23]. How this applies to the deployment of the proposed system is hard to explain, but a language model with the capabilities we currently see in models like GPT-4 should be considered safe to deploy if there are clear guard rails to avoid malicious actors from exploiting the system.

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[21] The end goal of these systems is to lay the groundwork for MNOs to have enough incentives to connect remote communities to the internet in a shorter time frame than would otherwise happen. The idea of standalone mobile networks is not in itself the end goal.

[22] There is an argument for this scenario where such an intelligent system could hold a certain degree of compassion and thus leave humanity alone. For more on these ideas refer to Bostrom (2014), Musk (2017), and the two reference to the Lex Fridman Podcast.

[23] Current AI systems could be thought of as extremely complex mathematical equations that adjust themselves based on some sort of human feedback. The result of such a self-adjusted mathematical behemoth is a great unknown as to how the system works. As of this writing this problem and alignment are the two greatest threats AI could pose as no one truly understands how the systems work. There is a recent proposition from OpenAI to try to solve the understanding problem by using more powerful AI systems to explain previous systems. This is a big risk as the system itself gets to explain what it does, nonetheless, I think this is a good starting point as we are completely in the dark. For more on this recent publication refer to Leike (2023).

Conclusions

The concept being explained in this essay is complicated as most of the economic analysis of such a deployment is along the lines of a good guess. A more formal analysis of this idea should follow if it is broadly considered to be feasible. I would argue that a complete analysis of such an idea should be done while building an actual prototype of the system as speculation on something that has never been tried out is high. Nonetheless, in the following lines, a full picture of what has been presented will follow with some final words on the business analysis.

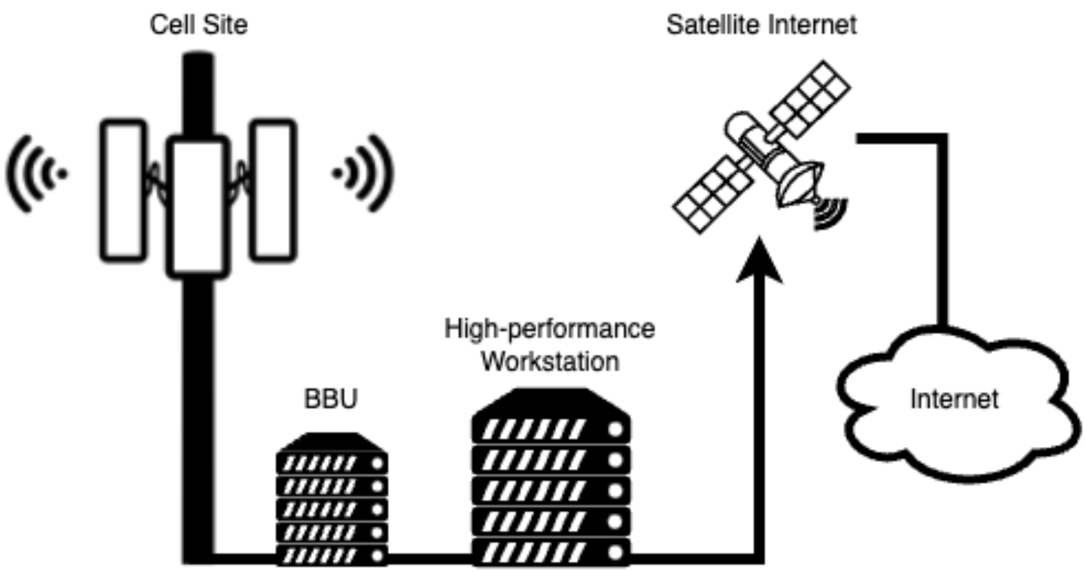

Figure 3. *Complete diagram showing how the completed system should work.*

The service is straightforward (Figure 3). There should be a normal base station with the capacity to work in the 400 MHz frequency range as to cover as much area as possible. The station should be connected to a high-performance workstation with a powerful AI model capable of solving some basic human needs like education and access to medical advice. The computer holding the AI model should have internet access via a satellite link that allows telemetry, communication in case of an emergency, and sporadic access to things that could in general improve the lives of people within the community.

The system would have a simple cost structure (Table 1), but analysis of this should follow more rigorous methodologies. As explained earlier, the best way of seeing the feasibility of such an idea is probably to go ahead and implement a prototype to start seeing how things could turn out. The three most important components in dictating the project's success are sane economic incentives for the MNOs to deploy such a system, government subsidies to help mitigate expenses, and ease of maintenance as to avoid sending highly skilled engineers to remote locations on a regular basis.

	Approximate Price (USD)	Description
Cell Site Construction	$60,000	This is the actual construction of the site, here tower companies could come into play.
Communications Equipment	$50,000	These include antennas, radio remote units (RRUs), and BBUs.
High-performance workstation	$78,000	This is the computer where the AI model will be deployed locally.
Two years of satellite internet	$8,500	This is how the system will get limited internet access.

Table 1. *A very simplified cost structure of how the cell site could look.*

The system as a whole would end up costing US$196,500 which is by no means cheap. To put this into perspective the cost of deploying a normal site to a location where ten miles of fiber-optic cable should be considered (Table 2).

	Approximate Price (USD)	Description
Cell Site Construction	$60,000	This is the actual construction of the site, here tower companies could come into play.
Communications Equipment	$50,000	These include antennas, radio remote units (RRUs), and BBUs.
Ten-mile Fiber-optic Cable Deployment[24]	$216,000	This is required to get complete internet access.

Table 2. *A simplified cost structure of what connecting a location 10 miles away from the fiber-optic backbone could cost.*

The total cost of connecting such a site would amount to US$326,000 which is very expensive. This expense will be a requirement if the world is truly looking to connect the unconnected without massive migrations to urban locations[25]. The fact that fiber-optic deployment would be inevitable and only around 50% more expensive than standalone mobile networks makes the new idea seem weaker than it really is[26]. An important factor that must be considered is that AI models are advancing rapidly; finding new algorithms that reduce compute intensity is possible. This relies once again on the magical effect of time plus human ingenuity, but it is entirely possible

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[24] As explained earlier this calculation is not that precise, the price could be a lot higher or somewhat lower considering different deployment methodologies. The current calculation is based on multiplying the price per mile of fiber-optic cable previously presented (US$21,600) times ten.

[25] This would be another way in which complete connectivity could be achieved, this would be very painful for the displaced people and thus not a great solution.

[26] Communities could be a lot more than ten miles away from the fiber-optic backbone.

that in less than two years this deployment price could well drop by more than 30%[27] considering both advancements in hardware and software. This would open a new scenario in which the deployment of the standalone mobile network could be priced at around $173,000, making it almost twice as cheap to deploy than the previously proposed connection of a location ten miles away from the fiber-optic backbone.

If the comparison in pricing is calculated in the way of *high-performance workstation plus satellite internet link vs ten-mile fiber-optic deployment* the argument for the standalone mobile network takes on a much more powerful stance. The difference between these two components is basically three times higher and this is without the consideration of any reduction in the necessary compute equipment. It is in this light that the comparison should be made. All the other equipment is necessary no matter the deployment methodology and would be needed even in future deployments.

To end things in a way that a clear picture of what is being proposed is left to the reader the complete argument will be laid out. Standalone mobile networks using AI models and satellite internet links could be a very convenient way to deploy connectivity to remote locations. This access to knowledge will improve life in the locations where it is deployed and thus improve the economic output of such a location. This rise in incomes would translate into more incentives for MNOs and internet service providers (ISPs) to deploy fiber-optic cable to these locations and thus end with a fully connected community a few years prior than it otherwise would. The people living in these areas would not only have a better standard of living earlier, but they would also have prior knowledge of how smartphones work and thus be more eager to adopt complete internet access once it is able to reach their location.

[27] This estimate is once again based on intuition but seems correct. However, a software advancement in AI models of such a scale is by no means guaranteed. A cool quote on intuition proposed by Albert Einstein is that “intuition is nothing but the outcome of earlier intellectual experience”, if this intuition is set to be true is something that only time—or a much more profound analysis—will tell.

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