The Internet as Infrastructure

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Preface

This essay is based on the talk I gave at the Internet Society meeting in New York on the Internet as Infrastructure.

For a shorter overview you can read "Thinking outside the Pipe".

History is replete with transformations enabled by new tools and infrastructure. The Roman roads may be been built for the military but the value was in facilitating commerce. Ben Franklin recognized the importance of a postal system in uniting a new nation.

Today the Internet has given us something entirely new. But just as the early automobile was a horseless carriage we can't understand the real impact of the Internet as long as we see it as just another telephone company or television network.

For a city like New York the Internet is as essential as the roads and the subways. For entrepreneurs it's about abundant opportunity to do what we can only imagine.

You can think of the Internet like the ocean. You can go anywhere you want without having to pay a provider. In fact that's just what happened with container shipping. The incumbent providers didn't control the paths across the ocean so they couldn't prevent innovators from taking advantage of the abundant opportunity.

Our ability to convert exchange information using an al-

phabet of bits, ones and zeros, has given us the ability to treat all of the radios and wires as if they are a vast open space. By confining bits to narrow passages (as with broadband) and by segregating wired from wireless bits we have given owners (the incumbent) carriers the ability to collect rent for merely letting us exchange a limited number of bits. The limitation is necessary to create value out of a "commodity" that is not a consumable.

This is not how the telecommunications providers see it. They are charging for services as if they were still in the business of carrying telegrams. But the paradigm has shifted and we now create the messages ourselves.

We need to shift from a rent-seeking funding model to a common infrastructure owned by local communities be they houses, cities, or regions.

The Internet has been such a generative force because we can concentrate on creating value (solutions) without having to limit ourselves to maximizing the profit of the carriers.

In going forward we need to be careful to understand that the legacy of the Internet is not the artifact of today's implementation but the idea that exchanging bits is distinct from exchanging ideas.

Shift Happens

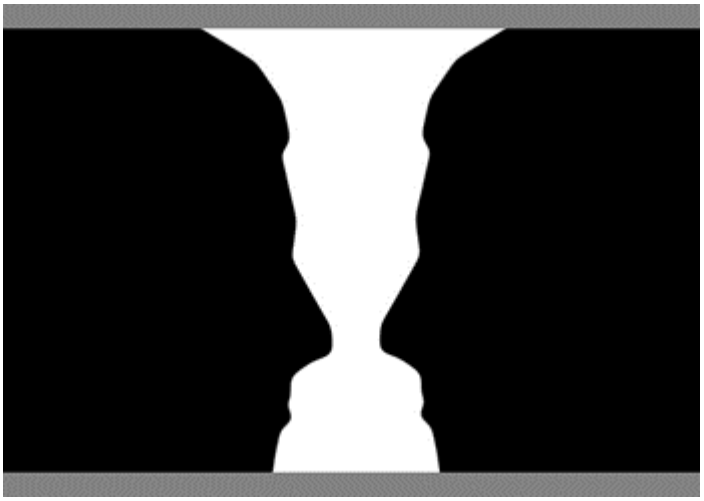
Seeing the whole

In music an overture is a prelude that gives you a sense of the whole before you listen to the details. In the same way the goal of this overview is to give you a sense of the whole so you can see where the parts fit in because meaning comes from context and we need to approach understanding from above as well as exploring the details.

By themselves the elements of the traditional service provider model reinforce each other.

The Internet is a very different paradigm from telecommunications. Bits are typically carried over the same wires and radios that the telecommunications industry uses to provide services so it's easy to see the Internet as a kind of telecommunications service. The name itself implies it's a network and, indeed, there is an implementation of the concept that has many of the characteristics of traditional telecommunications networks.

The same wires can be seen either as a telecommunications network or as just wires and radios we can use to create our own services. It's an interpretation in the same way



our brain interprets this classic optical illusion. It sees either a vase or two faces. The image is either one or the other. You perceive two whole images rather than a set of intermixed parts.

The Internet as a new concept

In the same way the Internet is a fundamentally different concept from telecommunications. We must step back and see the whole if we are to have the understanding necessary to capitalize on an idea that has transformed the world.

We can start with an operational understanding of the Internet as a new infrastructure alongside our roads and utilities. Like other infrastructures its purpose is to serve society. Once you think of it as infrastructure you realize it makes no more sense to try to make it a profit center in its own right than to shut down the subways because they aren't sufficiently profitable.

With that framing in mind we can step back to get the basic simplicity of bits – an alphabet of just two symbols: 1 and 0. We are so used to thinking of big systems as being complicated that it's hard to appreciate that the power of the Internet comes from its simplicity. There aren't wired or wireless bits. There aren't voice bits or video bits. There are just bits.

As I explain below, I'm attuned to simplicity because I grew up building systems. The entirety of the world-wide telephone system came down to two wires, one red and one green. That was all I needed to "operate" the phone system.

I had the same experience with computers. While still in High School I was programming online financial services. Implementing Dan Bricklin's VisiCalc I experienced firsthand what happens when people get a very simple tool to explore their own ideas.

Blank slates are the surface upon which we can write the future instead of accepting the limited choices provided to

use by, well, providers. We don't need to rely on theories and regulators. Instead we quickly try out new ideas.

I learn by doing. Computers and the Internet have made "doing" incredibly easy and accessible to all. All it takes to implement a new service is a little code. And I can create meta-services by exchanging bits among elements (such as devices) anywhere without having to deal with all the stuff between. That stuff can be a very complicated infrastructure of wires and radios and fibers that I can just assume.

Yet we see only a small portion of the potential benefits because the rent-seeking funding model we use to pay for this infrastructure forces me to have to convince all those along the path that it is worth their while.

The simplicity is undermined by being forced to negotiate constricted billable paths or "pipes". We are prisoners of the old paradigm of the telegraph wires (which ran along railroad tracks). We even go so far as to take the essentially unlimited capacity of wireless medium and reduce it to a limited number of imaginary pipes called frequency bands. It's a policy that dates back to the limits of 1920's technology.

I frame the new concept in terms of "bits" as the universal medium of bits as an alphabet. Knowing that bits can be used to represent information is an important part of understanding the new paradigm but it is not sufficient. After all we've represented telegrams and phone calls using electrons for nigh on two centuries. And we need wires to keep the information properly channeled along the path between two points. Or so it seems.

To really understand bits you need to recognize that though we do encode information in bits that there isn't a simple relationship between bits and the meaning we are trying to exchange. Just as we can understand a book without reading every word, we can send a message between two end points even if we lose many bits. And just like numbered pages in a book we can put the message back in order without relying on a pipe or channel.

Pipes!

In fact as I explain when I compare the exchange of packets (using a railroad metaphor) with driving (on roads paved or not) we don't even need a "network" operator. Each packet can find its own way and we can reassemble the packets like we can put the pages of a book back together again.

Escaping from the idea of the pipe is fundamental to our understanding of the future of the Internet. The economics of telecommunications are tied to monetizing the pipe. The business of carrying telegrams came first but the pipe itself became an asset as the business expanded to including the talking telegraph, AKA, telephony.

The pipe metaphor is at the heart of the common understanding of telecommunications:

- The regulatory model assumes that you can manage valuable messages by managing the pipe and, in doing so, create a service that people should pay for by the message.
- The business models assume control over the pipe for charging.
- Worries about congestion come from treating the pipe as a constriction that isn't subject to Moore's Law improvement.
- Pipe owners can make promises and guarantees. These can be monetized, especially when we assume that voice requires a managed pipe even though our experience with VoIP shows otherwise.
- Pipes are units of competition to the point where we assume that multiple pipes make sense because we confuse competition in services with competition providing transport for bits.

Traditional networking in the pipe mold is about preserving vital characteristics of the message. Every bit must be delivered reliably and, if we are to carry voice those bits must be delivered with very precise timing since even small shifts in timing are very audible.

The difference is that we don't depend on an operator because we can mark each packet so that we can reassemble them outside the network and handle missing packets very gracefully.

Each bit itself is like a letter of the alphabet and has no meaning out of context. The value comes from what we do with it outside the network. Thus there are no valuable messages to charge for. In fact, as we see, we don't even depend on every bit being delivered.

In *Thinking outside the pipe* I compare exchanging packets with container shipping. You don't pay the shipping company for the cost of shipping an entire factory. You just pay for the packets (containers) and assemble the pieces to create the factor yourself. You can even tolerate lost containers because you can ship replacements. Paying the shipper a premium is like overpaying for insurance.

The Internet evolves

One reason why it is difficult to adopt new paradigms is that we are solving different problems and, by measures of the old paradigms it seems like the worse choice in its early form. Even something so obviously valuable as the telephone, known then as the talking telegraphy, didn't seem

important because you didn't know anyone out of shouting distance.

Today we are used to having a lot of capacity so that we can even have video conversations. The reason we can do this with today's Internet and not the traditional phone network is that we didn't build in a special support for video.

It's worth noting that today's intelligent phone network is designed to handle video but it failed to evolve with the technology because the users couldn't make effective choices. Early Internet video was often very low quality but users could choose to pay more for higher quality. The phone network's video was stuck at modest quality at a high cost.

Initially the Internet could only carry traffic that didn't need much capacity and wasn't time critical. No wonder email was the primary application and, even then, a message more than a few dozen lines was often flagged as "long".

Voice wasn't a serious consideration. But even then the basic design of the Internet assured that it could carry packets of bits without knowing anything about what the bits meant. If some packets were lost it was the application's responsibility and not the network's.

Not only that, the application designer is limited to what works because there was no way to buy special treatment in the absence of a pipe. All you can do is buy more capacity in the local network and, perhaps, the next connection. A university, for example, can cooperate with other universities to buy more capacity for all.

This decoupling of money from the path was forced by the original design point – interconnecting local area networks which were really just wires used to exchange bits. Thus the funding had to reflect the decoupling of meaning from the bits even if that decoupling was not fully appreciated. In fact even the term "The Internet" reflects the idea that it's still a network.

The transport could only be funded as a common facility. This forced a separation between applications and the transport. You were limited to what works using the available facilities.

In 1993 the World Wide Web burst upon the scene. It took advantage of the Internet as a blank slate and created a new blank slate giving people tools to create their own webs. The Web itself was just one more experiment building upon the experiences with predecessors such as Gopher. While we can analyze why the web got it right, what is important is that the Internet made it easy to keep trying and then to share the results.

Misattribution

We do need to be careful because it's easy to take away the wrong lessons by observing the accidental properties of the artifact of today's Web rather than understanding the dynamic process that birthed it.

We see this today in crediting "broadband" with the power of today's Internet when we exchange bits despite such impediments. Instead of recognizing that we can do voice thanks to the capacity created to support the web many people assume that voice only works because of special policies inside the network that give priority to voice bits.

In fact it's just the opposite. Such policies have made the overall behavior of the Internet worse. One example: if buffer bloat (which I discuss below in the section on Congestion).

What was important is that demand has created supply. One big reason is that we were able to take advantage of any opportunity to exchange bits. We were even able to repurpose systems designed to distribute video content – DSL and "cable".

Unfortunately most people didn't understand that this was a repurposing *despite* the architecture of these systems and the associated business model. While it's a testament to the power of the idea of the Internet it has also stymied the transition by extending the story of the old paradigm.

We see this in the extreme with today's smart phones which are hobbled by very problematic infrastructure tied to a business model which is about billing and not about serving the most basic needs of society. The profitability of the pipes is threatened as the value moves outside the network and any attempt to open up alternative paths such as Wi-Fi undermines the story that we call telecommunications. Thus the carriers have every incentive to limit capacity which works at cross purposes with the goal of "more Internet".

The same thing is happening in broadband as we see with FiOS. Verizon is trying to reduce their costs because it isn't working out because they can't make up for the costs of the transport by selling more video content. Comcast has shifted their assets to the content business by acquiring NBC Universal.

This is why there must be a transition – we are reaching the point at which the story of telecommunications breaks down. In fact it has but we have a regulatory system whose primary purpose is to maintain the status quo.

We are caught up in our own myths (or, to use a colloquial term, bugaboos). To fully appreciate this we need to understand the possibilities created by having the Internet as a new infrastructure.

To understand this I describe the basic concepts we need to understand bits and then examine the bugaboos which keep us from seeing telecommunications.

Paradigm shifts don't have straight paths but we can look at some ways in which the transition is already occurring.

While this essay focuses on the Internet the principles of creating opportunity (the blank slate) and creating an effective marketplace by decoupling system elements have far wider implications. As we understand how we build solutions using bits we get a better understanding of how systems work and how they evolve. In fact we can apply the lessons to other digital systems such as DNA-based biology.

Our New Infrastructure

in·fra·struc·ture (in-fruh-struhk-cher) The basic physical and organizational structures and facilities (e.g., buildings, roads, and power supplies) needed for the operation of a society or enterprise.

Infrastructure exists to support the community rather than being an end in itself. In order to understand the contribution and potential of the Internet we need to see it as a common infrastructure rather than a collection of private pipes owned by carriers.

It is the antithesis of today's telecommunications industry (including broadband) which is about confining our communications to narrow pipes for no reason other than making all paths billable as if we were still using 19th century telegraph wires.

We can compare it with sidewalks, roads and bridges:

- Funding infrastructure as a profit center compromises its value to society.
- We fund streets and sidewalks for public use yet we lock away the wires and radios so we can bill for their use!
- Imagine shutting down the New York subways because they were not profit centers.

Even though the subways are not run for a profit people pay to take rides just like they pay tolls on some highways. While toll money goes to pay for those highways we don't put tollbooths on city streets and we don't set tolls so high that they compromise the larger purposes of the road system.

This makes the idea of charging merely to talk among ourselves, that is, to communicate so anomalous. The wires (including virtual wires, AKA radios) cost a very small fraction of what roads do yet we've worked hard to limit access to assure that the wires are profit centers and in doing so we've greatly compromised their value to society.

The Internet has been a great success because it has given us the opportunity to focus on applications and experiment with new ideas without having to justify our efforts to a third party.

In practice the story is not so simple because we've built the Internet by repurposing the existing telecommunications infrastructure. Where we can buy bulk capacity, as in "broadband" subscriptions we are free to experiment.

When we try to apply these solutions more generally we find we have to pay for passage by creating billable events. It's hard to innovate when each device must have a separate relationship with a provider so that it can generate a billable event or when devices can't even communicate unless a human opens a browser even if only to click "agree" as if bits were dangerous cargo.

Our economy suffers because we don't understand the new concept of "bits" as a common alphabet that we use to create new industries on a common infrastructure.

We build separate systems for each purpose and not only lose the synergy of shared facilities; we lose the ability to create a city that is more than the sum of its parts.

It's as if we've walled off the neighborhoods and each street and storefront could only be used for a designated purpose and connect with others according to strict rules. We should honor Jane Jacobs memory and recognize that the richness of a city comes from the interactions we cannot anticipate.

If you look around, you see hints of what is possible. Today's cellular phones generally have the ability to dial emergency (9-1-1) calls even if you aren't registered with a particular carrier. But that's possible only where you have cell service and only works for voice calls. Your medical monitor can send a message even if you lose consciousness.

You can run a program (like Wi-Fi Analyzer on Android phones) that shows many access points all with different policies. It's as if we've taken a vast commons and turned it into a tangle of twisted narrow passages for no reason other than our being prisoners of metaphors that no longer

make sense. We presume scarcity and thus deny ourselves the abundance as if we were worried about using up the alphabet if we wrote too many words.

You don't need to understand the technology to recognize that how we fund infrastructure makes all the difference in the world. If we have a funding model that requires each brick be a profit center, we'd never have a road system. If we made each bridge a profit center a few would get rich while the towns around them suffer economically.

The value of infrastructure is in its value to society rather than how much money an owner can extract. This means we need a funding model that is external just as we pay for road as a public good using any source we can. We use general funds and we may supplement them with other fees such as tolls as long as people see the value and accept the payments as just. These fees do not necessarily corresponding to costs, just with people's willingness to pay.

The fundamental problem we face is that we do not understand the value of bits and instead take our abundance and lock it into services or parts whose value is far far less than the value of the whole. In fact, I argue, the vast majority of the costs of communicating come from this effort to channel our interchanges into narrow billable paths whose value, to the owner, is threatened by abundance. We needn't continence such policies.

Understanding bits and the Internet

My Journey of Simplicity

In the 1960's I discovered that telephones were connected to the world by two wires – one red and one green. What could be simpler?

In 1963 I was in middle school my mother was teaching at Hunter College. I took her in place in the faculty class on programming the IBM-1620. Fortunately for me I happened to be simpatico with these new computing devices.

Computers just deal with zeros and ones. You just move them around and combine them. The 1620 didn't even do arithmetic – it had to look up 1+1 in a table.

By 1965 I was using computers at NYU in the very building where I gave my talk. The CDC-6600 you see in the picture was the supercomputer of its day. Yet, in its heart, was the simplicity of ones and zeros.

In 1966 I got a job with White-Weld (later Interactive Data) offering financial information online. We started by using dial-up phone lines and then, like others, we built our own network using our wires and those we leased from the phone company. We didn't buy networking as a service.

Later at MIT we studied various computer systems. One was the phone company's ESS (Electronic Switching System) as just another computer system using the same ones and zero and the same copper wires we used to do our own networking.

In class we also studied the ALOHAnet that used unreliable radios to exchange bits among computers. It wasn't really a network; if a packet of bits got lost then your program would just resend the packets. One my classmates, Bob Metcalfe, built on this idea but confined the radio waves to a wire. He called it Ethernet. But it wasn't really a network in that there was no provider. It was just like the ALOHAnet in that you just exchanged packets of bits and if a few got lost it was no big deal.

The no big deal is in fact a big deal. It decoupled the application from the way we exchanged bits. Instead of a myriad of different network services and plans we just exchange bits. No matter what we were exchanging it came down to bits.

In the 1990's the web was new and people wanted to be connected to the Internet in order to reach web sites. The service providers wanted to provide more access to the web as a billable service just like phone calls. In fact ATT went so far as to pay a high price to buy MediaOne because they thought they could garner some of the money from Internet commerce. The PC would be treated just like the set top box with a monthly fee and rules on what you could do. If this sounds familiar, it's because it is the model we have today for cellular phones.

I was working at Microsoft at the time and decided that there was nothing complicated and Internet access would be DIY (Do It Yourself). I just had to remove anything that made it complicated like installing special software or negotiating with a provider for each PC.

In order to sell the idea to others at Microsoft I sold the idea as shared access to the web but I was careful to take an infrastructure approach to the point that Microsoft would not be able to charge for merely exchanging bits.

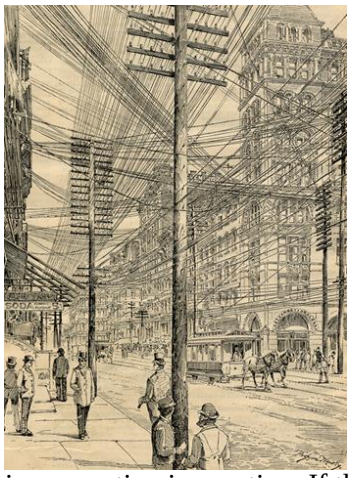
The bits only became billable when they left your home and entered the century old business model of telecommunications.

The result is that you can freely connect as many computers, printers, phones, screens and other devices to your home network as you want. You can watch a movie over your home networking without worrying about running up a bill.

Parts without the Whole

In the future you will also connect your smart meters, medical devices using this same Internet. The idea of separate networks for each purpose is not sustainable.

The reason connected devices are not common today is that we treat each problem as if it had to have its own infrastructure. We see this with the so-called smart grid that needs its own expensive infrastructure. While I can understand that there is money to be made in selling us yet another infrastructure, the question is why we are willing to pay again and again while getting no new value in return.



We haven't come far from the 1880's when there was a separate wire for each phone. We've bundled them together into "broadband" pipes with one from each "provider" as if the Internet were more than just a way to exchange bits.

The problem is not simply the cost of redundant infrastructure and spurious billable events. The real cost is in preventing innovation. If the smart meter is an extension of the electric utility, then innovators have to ask "may I" before creating applications that allow you to manage your own home.

I used the word "innovator" instead of "entrepreneur" to emphasize that the new ideas don't have to be in service of a business model. The idea that every innovation must be a profit center can work again profiting society as a whole.

Readily available general purpose computing and common facilities for exchanging bits allows for rapid experimentation with new ideas without requiring high risk and high cost investments.

There is also a second-order effect. If we don't have to justify large investments it's easier to share benefits with others. The Web is a good example, because it the existing Internet it was easy to make it available to others.

The Blank Slate

A blank sheet of paper is more "valuable" than one with printing because we can make the blank sheet be whatever we want it to be. That's not really true; it's only potentially more valuable while the paper with printing has the known (or realized) value of the content.

Electronic spreadsheets are a prime example of this though the example isn't as powerful as it was in the 1980's when the ability to play with numbers was new. The spreadsheet is modeled after the back of an envelope as a scratchpad for working out ideas. It has little knowledge in its own right. It provides a user with tools to leverage their own expertise. While there have been many attempts to "improve" on the basic idea these improved versions find themselves limited to niches.

In the 1970's IBM settled a long-running antitrust case by agreeing to sell computers rather than leasing them with bundled software. This made the hardware much more valuable to society though not necessarily to IBM. This became very clear with the personal computer. Eventually IBM dropped out of the personal computing business to concentrate on creating value using computing to solve business problems.

To those used to high margins it seems as if you can't make money by selling blank slates, that is, commodities with little intrinsic value. Yet companies can succeed at the business by controlling costs and getting volume. Or they can take another path and limit supply as we see in the dairy business. When there is too much milk the price drops below cost.

Another take on this idea is "seed corn". We talk about eating the seed corn as a desperate act that comes at the cost of next year's crop. A farmer would do this reluctantly because it means that there may not be a crop next year.

On the other hand businesses often choose to control the supply of the raw materials to force others to buy high margin products by limiting competition. This is a form of monopoly but it doesn't violate laws aimed at the simple framing of the 19th century railroads[i]. The analogy with railroads does keep reappearing and it is appropriate because they were that century's equivalent of the telecommunications in the way providers both created and limited opportunity.

For commodities whose value is to society only as whole we can't rely on local profit centers because the whole doesn't necessarily exist in those parts. This is where we need to fund the whole as infrastructure.

The problem with today's concept of telecommunications is simple. We're trying to sustain a profit-center model by

forcing providers to limit the capacity in order to create value.

We compound this by continuing an earlier value-added model in which we are denied access to the basic resources, the blank slate, because we're still in the telegraphy mindset. The very word "communications" implies that the providers are carrying valuable information, that is, communication on our behalf. Now that we can represent information using bits the carriers no longer have an exclusive on added value. They are now competing with users who take advantage of the commodity bits to outcompete the carriers because they don't have the burden of having to fund a private infrastructure.

We've been hiding this behind a regulatory façade that makes a Potemkin village luxury housing by comparison. And all for naught or less than naught as we are taking value from society in order to sustain this irrational business.

By simple decoupling the business of using the infrastructure from the infrastructure and funding the infrastructure as a whole we will no longer have a need to create scarcity out of abundance merely to maintain an irrational marketplace.

We should embrace creative destruction instead of fearing it. The Internet has given us a hint of what we have to gain.

What is amazing about the Internet is how quickly cooperative behavior and emerges. The web is but one example. Unlike complex social systems we can look at the parts and get a sense of how this process works at various levels.

We can use Internet is a laboratory for studying how stable behavior emerges from how we interpret the elements of the system. The bits themselves have no intrinsic meaning but we can assemble them in patterns that do. In effect Tim Berners-Lee gave us a set of rules from whence today's web emerged. The same thing happens in nature but it's far harder to discern the process amidst the complexity of biological systems.

The "discovery" of bits

It would be interesting to explore the evolution of generic computing and the mathematics of bits as described by Claude Shannon.

In this case what we discovered with bits is that we can use them to represent any information we can exchange over a wire. It's the alphabet we use to communicate. The letters themselves are just characters – the meaning is exchanged between the writer and the reader. When you read a book you can choose to skip pages or read past typos. You don't need to see every word and, if you are in touch with the author you can also ask for clarification.

It's the same with bits. They are a means of exchanging information but the conversation is between the people (or devices) and we can deal with missing bits and misinterpretations.

The Arpanet did encode information in packets but the network took responsibility for reliable delivery. The ALOHAnet was very different in that the responsibility was in the application rather than the network. We saw a similar idea explicitly in the form of Datagrams in the French CYCLADES research network.

More to the point, as we've seen, Local Area Networks (LANs) were nothing more than wires and radios carrying packets. Researchers (most notably Vint Cerf and Robert Kahn) were confronted with a problem in interconnected LANs. Unlike the Arpanet the network could not take responsibility for the reliable delivery of the packets because they didn't know about any organization higher than the individual packet of bits.

A key insight was that you could get a reliable connection without a reliable network. Of course like many "discoverers" this is now obvious and we were already doing this with packet networks and even before that using various techniques for correcting errors. This idea was explained as "End-to-End Argument". We need to be careful to understand that we mean that we can communicate without depending on the provider of the path understanding the message. The term is often confused with womb-to-tomb which means just the opposite because having the provider responsible for the message gives the provider the ability to charge for that valuable service.

The big surprise is that you can carry on a voice conversation without depending upon the network for assuring that the speech is preserved. What makes this more difficult to understand is that you can't guarantee speech will work and it doesn't unless you have enough capacity to increase the odds of each packet getting through.

We can contrast the End-to-End approach in which there are no promises and you have to discover what works with another network architecture that guarantees phone calls will work and that you can hear the other person – today's phone network or PSTN (Public Switched Telephone Network). The price for such a guarantee is very high:

- The network "knows" it is carrying a phone call so you can be charged for that call in "minutes" (even if you aren't saying anything).
- In order to guarantee a call will sound good the system reserves capacity which means that you

can't make a call if the capacity is not available. This means it isn't a guarantee at all, you just have to be a winner by being lucky or by paying more than the next guy.
- The promise is called "QoS" or Quality of Service. It's really a measure of how little capacity the phone company can give you while still carrying speech. If any element of the path fails the call fails. Most important, if the billing relationship fails the call fails.
- You can only do phone calls as per the promises. This means you can't take advantage of additional capacity as Skype does to give you higher quality or video when the capacity is available.

It may seem counter-intuitive to give up on promises but the Internet approach has worked so well that much to-day's phone traffic goes over the Internet. Yet the phone companies are still charging us as if they still had their high cost network!

The reason why the phone companies need to charge for phone calls goes back to the problem of selling blank sheets of paper. The phone companies started out as tele-graph companies carrying paper with valuable messages. You need a different business model in order to sell blank paper by the ream.

We exacerbate the problem by empowering a single com-pany to both carry bits (blank sheets of paper) and content (telegrams). There is an intrinsic conflict of interest in this approach. We must decouple the two if we are to have an effective marketplace.

It's painful to see ads for "more reliable Internet" [sic] as if the Internet is another TV channel. I also pity those who call up old line carriers for computer support. The support staff typically lacks effective tools to manage their own network services let alone diagnose problems on people's home computers that might not even be network related.

Exchanging Bits

I've tried to be careful in talking about exchanging bits to avoid confusing "communications" in the sense of ex-changing information with the more basic infrastructure.

We're still thinking in terms of telegrams (AKA, message units or minutes) using a railroad metaphor in which a phone network is very much like a railroad. If you look at this diagram of the phone network from 1909, it looks very much like a railroad map.

We accept the railroad (or pipe) metaphor. We also ac-cept the idea that the Internet is a consumable because it's carried on wires like electricity but how can you use up the supply of ones and zeros?

Yet even with a railroad metaphor we did our own routing with the phone dial – each digit was equivalent to choosing our own path through the system. Today the phone number is an abstract identifier, but we mustn't forget that it was an implementation of what is now called "source routing" (for you geeks).

We also accept the idea that we "access the Internet" as if the Internet were a place far away. Thus it makes sense to buy a ticket or pay a provider for services.


TO THE RIGHT AND WEST.

A better metaphor is sidewalks or roads. There is no single system. We just have local roads that interconnect. In fact a hundred years ago we didn't have road maps. Instead Rand McNally published books of directions with descriptions and pictures that look very much like today's Google Streets.

It was Rand McNally that started painting road numbers so that people could find their way. Later states adopted the practice so that you could just follow Route 1 to get to your destination. Thus we created the illusion of a road system out of an assemblage of parts.

Actually it's not an illusion. The system is real but emergent rather than a physical system. This is where our language betrays us because it doesn't bother us with distinctions that don't seem to matter. The word network is used for social networks as well as managed networks. No wonder we confuse the two.

You can think of the packets compromising a conversation like a team in which the members take their own cars instead of being in a single train. Each car can take its own route and we can still play a game as long as enough players show up even if not all of them make it through.

To an observer it may seem the same in that the team gets from point A to point B but in reality it is very different. This confusion is subtle because the resilience that comes from not depending on a provider's promises makes it look like someone is indeed assuring reliable delivery. In fact we understand the message because of our language skills, not because the provider has kept every bit perfectly intact.

We see this same kind of confusion in science where the uncertainty that makes us check our results against reality gives science the aura of certainty.

No wonder we think we need service providers. In fact we go further, we expect a company like Comcast to also support our PCs because they are connected to Comcast's network. We also expect to fix social problems such as trust within the network.

Spectrum

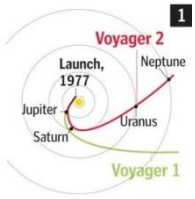
We can see the problem with the pipe metaphor in spectrum policy. The idea of assigning radio frequencies makes as much sense as forbidding two people in the same room from wearing the same color shirt because we can only distinguish people by the color of their shirt.

Even if we did we would need to allow technology to improve so we could distinguish between the myriad shades of blue with increasing precision thus allowing more people into the room. But we don't just look at the shirt color; we look at the entire person. If two people look identical then we accept that as something we deal with socially rather than by regulation.

Spectrum policy might have been a convenience in the early days of radio but that convenience came at a high price. We accepted the idea of licensing speech and the idea that there can only be so many voices heard.

We also know that it takes 50,000 Watts for a major AM station to reach viewers yet the 25 Watt 1970's vintage radio in the Voyager probe can still be heard from billions of miles away.

If you relay your bits via a nearby access point you can use 25 milliwatts or less and reach the entire world. You can listen to essentially any radio station in the world over the Internet over a narrow Wi-Fi connection but you can only listen to a handful of radio stations using the licensed spectrum.



The biggest problem is the idea that we need a separate regimen for wired and wireless bits. Instead of having to compete for access to a distant tower, why not whisper to reach a nearby access point?

Once again we find ourselves prisoners of a bad metaphor.

The fallacies and failures of spectrum allocation are simple to observe once we understand that radio waves pass through each other and interference only arises if we ignore the rich information available.

While we have many stakeholders, including a government that sees money in selling off colors, change is possible. Switching from analog to digital TV signaling was a total waste but it showed how radically we are able to effect change once we decide it is worth doing.

Replacing antiquated analog radios with ones that can tap into the richness of digital signaling, *i.e.* the Internet, provides so much advantage that there should be little resistance to change. And that change can be incremental because the digital signals can co-exist with analog signaling. In many cases the power would be so low as to be invisible to older radios since we just need to send a signal a short distance to the nearest wire or fiber yet reach the entire world.

It's not a Network

In the 1990's the term "home networking" was ambiguous and I found myself working on home control – how do you connect the elements in a home?

One lesson is that we need to be able to define stable relationships between end points, be they a light switch and a fixture or two people on Skype. This relationship is entirely outside the network. Yet today's Internet protocols depend on the IP address which is a network-centric identifier and it depends how and where you are connected to the network.

We need to reinvent the Internet from the edge with protocols that support stable relationships independent of the path. Such protocols allow us to escape the pipe metaphor and take more advantage of the abundance around us.

It also allows us to escape the idea that "mobile" is something special. What is strange is that we are still using protocols that date back to the days of mainframe computers that couldn't be moved.

To put it simply – the Internet is an idea. It is only a network in the sense that our friends form a social network. We should not be trying to solve social problems such as trust within a network. (Nor in Facebook, but that's another issue).

We also need to get beyond the idea of a smart home (or a smart city). The smarts is neither in the network nor the home network. My medical monitor should "just work" whether I'm at home or anywhere else. It should work without having to authenticate myself to a provider.

By having a common bit-exchange medium we create the opportunity for all sorts of new devices. We don't need a grand agreement but can each implement our own devices and protocols and then attempt to get others to join us.

This is a very powerful dynamic. The web is just one example. It happened because we already had a common transport for bits in the existing Internet. Tim Berners-Lee's decision to make the encoding language, HTML, open allowed others to experiment and evolve the protocol.

Contrast this with the years it took carriers to interconnect their messaging systems because every system element along the path had to do just the right thing and any variation caused failure.

The lesson of decoupling system elements and solutions that work opportunistically are applicable far beyond "networking" as such.

Instead of designing smart systems that try to solve entire problems we need building blocks that allow anyone to innovate. It's another example of the power of the blank slate over a piece of paper with a printed form that can only be used one way.

Bugaboos, Stories and Paradigms

Bugaboos

The worries and concerns that make us resist change.

Government

I find it strange when people object to an infrastructure approach because they believe government can't do anything right.

Today's telecommunications business is defined in the minutest detail by the FCC and its regulations. You are even told what words you are allowed to use! Worse, the government acts to protect the incumbents by making it difficult, and often illegal, for communications to talk among themselves without paying a provider.

An infrastructure approach returns us to government as a facilitator. It could be a city government or a condo-board. Keepings bits flowing is very simple and transparent and government's role is largely hiring those who can deliver most capacity at the least cost.

It's far simpler than maintaining roads and also far less expensive. Furthermore by using a common infrastructure the city will save money.

Private companies see users as competitors because a provider loses money when customers can solve their own problems or buy from third parties. With an infrastructure approach users are not competitors because any capacity adds to the commons and the community is not trying to fund the infrastructure by forcing people to buy services.

To put it very simply – we're not asking the city to run complex brittle networks. We're asking for just a little help keeping the bits moving. And, as we've seen with home networks, just about anyone can do that.

The very competitive market for supporting infrastructure will lead to rapid evolution of approaches that are resilient and self-healing.

Just to see one example of this. Today routing packets is considered complex because each carrier is trying to minimize their use of other carriers' networks. They then have to settle out the charges by paying each other. The settlement or transfer prices leave much room for manipulation while creating complexity. This all disappears with an infrastructure approach.

Congestion and Scarcity

Pipes fill up so it's natural to worry about the Internet pipes filling up or getting congested if we don't have controls. A subscription is supposed to act as some sort of

congestion control. Very simply, if we don't have pipes then we don't have constriction points.

Even when we don't have pipes it's hard to escape the assumption that there will be a constriction somewhere in the path. This fear isn't entirely irrational because at any point in time our facilities and technology do have some limits on capacity.

If we framed the issue in terms of opportunity instead we find that Moore's Law is really about technology creating supply. This only works if we are very tolerant. Initially we only had enough capacity to exchange email but eventually we find that the value of simple applications like email and the web drove the market to create enough capacity for voice to work.

One way to increase capacity is to improve the technology. In the same way that a silicon chip that used to do millions of computations per second now does billions a wire that once carried a single phone call can carry millions if not billions of bits per second. We also gain capacity through cleverness. Skype makes far better use of the available wires than a traditional phone network.

Some of the concern with congestion stems from experience. The path can indeed become clogged with bits under certain loads as when people use torrent protocols. Torrent protocols are actually very good protocols in that they take full advantage of the paths available rather than limiting the flow to a single train of packets.

It turns out that under investigation the problem was not congestion itself. Just the opposite! The carriers wanted to help out by buffering packets along a path. This is like putting parking lots at intersections on highways in an attempt to reduce congestion. It doesn't solve the problem but it means we can look out and see the traffic and adjust our behavior accordingly!

Another form of this concern appears in the guise of promises of performance on the assumption that voice conversations are highly sensitive to delays so the network must carefully manage the traffic flow. In practice it turns out that voice of IP works without such promises. Even within the pipe model providers can't make promises because they don't control enough of the path. And if they tried they would have to reserve a lot of extra capacity thus exacerbating any congestion there might be.

Yet despite all the complaints about scarcity millions of people subscribe to Netflix and other streaming services. Something is wrong with the scarcity story.

The secret is that we don't rely on promises but instead discover what we can do with the capacity and opportunities available. Because bits are bits one application (like voice) benefits from the increased capacity added to support the web. This is the virtuous cycle that drives Moore's law-style hypergrowth because local stakeholders invest in creating generic capacity.

But service providers benefit from scarcity so we see a lack of improvement. DSL, for example, has improved little in 25 years in the world of telecom while Ethernet wires in the home have improved by a factor of 100 as the prices for network gear have fallen by similar amounts.

The key is to avoid telecom-metric and instead recognize that the Internet is something different.

We see similar fear in the idea of public infrastructure because we don't believe governments that run complex public systems such as water and sewer can do something as simple as hire people to keep the bits flowing. What makes this ironic is that today's telecommunications system is a creation of government while infrastructure is owned by the local community which can invest for its own needs.

An infrastructure approach is market driven in that we are able to choose how to add capacity. Governments act only as a means for community action at the scale of a city. Since we're talking about just bits and not content (like voice) the system is very transparent unlike today's telecommunications system which requires extensive regulation to limit the harm done.

Instead of being afraid of change we can do controlled experiments and shift to an infrastructure model in various communities and observe the results. Actually we've done the experiments in our homes, campuses and businesses and it has worked out remarkably well. We can do much better but not if we shackle ourselves to the dogmas of telecommunications' past.

Transition

How do we get from here (telecommunications) to there (infrastructure). The approaches are not exclusive. The infrastructure in local networks interconnects with today's services model once they leave the campus or home.

In fact this is what happened with the Internet itself. Instead of building a new "Internet" we started out by leasing lines from the phone companies. I'm not talking about building new infrastructure. We just want to get the bits flowing. While we can do this most effectively by using the raw wires and radios we can also pass the bits through the existing telecommunications infrastructure as we have done with the Internet.

We can see how this works with today's broadband. Once one pays for a subscription we can consider the bits free.

The limitations of today's telecommunications business mean that we can't just assume connectivity but where we have it we can concentrate on our applications. We're just extending the degree to which we can assume connectivity rather than building something entirely new.

To put it simply – we have connectivity now and are using it now. There is no barrier to doing more other than the limits of our imagination.

Efficiency

The goal of a telecommunications provider is to make efficient use of resources. But what do we mean by efficient?

Even if we look at one of the most obvious examples we find that the measure is not obvious at all. If we keep a wire utilized 100% of the time it seems efficient but not necessarily in the domain of bits. Is a wire carrying a thousand bits per second all the time more efficient than a wire carrying a million bits per second only 1% of the time?

Another example is those who argue that broadcasting is more efficient than the Internet's point to point connections because a single program can be broadcast to a million people at once. But is it really more efficient to force people to drop what they are doing to watch the broadcast and to deny them their own voice?

Efficiency is really a ratio, that is, a measure against some metric. When we know the metric we can use such measure to guide our decisions but we need to be cautious about measures that lock us into more of the same as we fight over a fixed pie.

We see an example of this in the attempt to auction off the radio spectrum (frequency bands or colors). In the 1960's Ronald Coase suggested that we auction off frequency bands without limiting their purpose. That was a good idea before we understood bits. Yet we are still optimizing spectrum use against 1960's measures as if we've learned nothing since.

Perhaps this is why pipes, be they frequency bands or wires, are so attractive. They make the math so easy that we forget the results are meaningless.

Competition

A cousin of efficiency is competition. Here again the pipe metaphor leads policymakers to treat competing pipes as effective competition. It is competition within a very limited model, one that denies us the larger value we can get from exchanging bits without such restrictions.

Here too we see larger societal issues as we measure competition and efficiency in terms of profit. But society is more than the sum of its parts and the value of the whole is more than the profits of the parts as we see in the blank slates that have little value in isolation.

Achieving Infrastructure

Enum and Transparency!

I'm listing Enum first because it is such a powerful leverage point. The entire voice telephone business rests on the carriers' ability to control phone numbers! The exclamation points are justified because there is so much resting on Enum.

In the United States you can endure the cumbersome process of "porting" a phone number from one carrier to another if your number is, in fact, allowed to be ported. There is also a fee associated with porting and it can take a few days and some paperwork. Even if you do port the number you must port it to a company that is an approved provider.

Why are phone numbers any different than a domain name on the Internet? I can change any aspect of "Frankston.com" myself. I can change how I handle email or move my website simply by changing a table entry I control.

Just like ".COM", there is ".ENUM" which for phone numbers. I would have an entry like 15551234.enum and could point it to Google Voice or even my home computer.

Of course most people would choose to let someone else manage their entry like they do their websites but the ability to do it yourself assures a competitive market.

Today I can choose a number of different providers to handle phone calls on my smart phone. I can install an application and the call will be handled using whatever path is available without costing me "minutes". But it's currently too difficult to manage this and I can easily lose control during the porting process.

The ITU has given various reasons for limiting Enum adoption. We saw the same thing happen with number portability with the carriers claiming it would cost six billion dollars even when they were already looking up numbers in tables.

The reason for fighting against giving users control over their numbers, a modern form of identity, is very simple. If they made it too easy to move ones numbers and to use programs that didn't use "minutes", few people would pay for voice calls.

We saw a prelude in the 1970's when MCI challenged ATT and allowed people to place less expensive calls by

dialing through MCI's network. Over time it became relatively simply to place calls using the carrier of your choice and competition did work well – at least within the parameters of the telephone network.

The idea of charging for phone calls still persists thanks to the remaining barriers to choosing how your calls will be handled. The cellular industry has given the phone companies a temporary refuge thanks to their control over the device we call a cellular phone. The device itself is not very different from the PC in your home except that you don't have many of the rights a normal owner would have.

Adopting an Enum approach would remove the friction from choosing how your calls are carried. To get the full benefits your cellular carrier shouldn't dictate how you use the instrument. This would require making a carriers' financing of the instrument explicit rather than hiding the loan within an opaque monthly bill.

After all, if bits are indeed bits why do relatively few bits in a phone call create billable events whereas email doesn't? For that matter why does do SMS (text) bits cost millions of times what a "broadband" bit costs.

With transparency such anomalies would be hard to sustain and would lead to a rapid restructuring of the industry.

Just to give you a sense of how many different ways there are to place calls on my cell phone I have apps for:

- Truphone
- Toktumi also known as line2
- Ooma
- Google
- T-Mobile's own Cellular over IP.

There are many others. In fact anyone can setup their own server to provide their own voice services.

Once we can assume Wi-Fi coverage there won't be any need for voice "minutes" because we wouldn't need to use a provider's network at all. All we will need is a portable computing device. Unlike the standard cellular carriers the VoIP providers typically provide software for ones computer in addition to supporting multiple handsets.

The first stage is one for one replacement for today's telephone services but we will expect to see very rapid innovation as with Apple's SIRI service. The problem for carriers is that the competition is not just on cost but on innovation.

The Carriers at the Forefront

Perhaps the biggest driver for change will be the carriers themselves. In the 1990's AOL focused on the business of content and access but it sold off their network because the money is made using the network not owning the network.

The telecommunications business model of charging to carry valuable cargo no longer makes sense. The value is now 100% external to the network.

Though the "Cable TV" business may have had its origins in relaying distant TV signals through a community antenna, players like Comcast and Time-Warner (HBO, Showtime) shifted their focus to owning content as well as being a broker for others' content. They've shifted their focus from the cable with Comcast buying NBC Universal and Time-Warner spinning out their cable division. British Telecom has been spending heavily to shift their money to new businesses.

Verizon and ATT come from a different culture and have had difficulty in making the transition from a networking company to a content/services company. This is why Verizon is trying to reduce costs for their FiOS division.

They have had trouble trying to make money in the content business but they have the "chops" problem. They may have the technical skills to run a network but the content business is something else. They are newbies. Yet if they could make money in the content business why would they want to have the burden of owning a broadband network that others can use for "free" (that means without giving them a portion of the value created using that network)?

The business of owning a pipe to transport bits is a natural monopoly. This is not the natural monopoly that ATT managed but a local natural monopoly akin to the electric power grid but without any consumable. Something is wrong when the service providers can charge enough to sustain multiple broadband distribution systems with wires let alone multiple wireless systems that are kept separate.

But it doesn't even make sense to confine bits to pipes so the very idea of an exclusive owner of the infrastructure is not sustainable. Anyone can exchange bits using any path.

And the carriers (at least senior managers and technically savvy employees) know this. They are simply trying to stay one step ahead of creative destruction. That is what they are taught to do in business school

In the 1980's the carriers realized that voice revenue was going to go to zero and that once people had a cable for video why have a separate copper wire just for phone service? Their first effort was ADSL – taking the copper phone wire and upping the speed high enough to carry video. But it wasn't enough so Verizon spent billions putting in a new fiber *distribution* system. Note the emphasis on

distribution. The ADSL got repurposed as "Internet" while the cable companies offered their own Internet service.

Just as we now use "cable" to mean the content business, the term "broadband" no longer refers to a technology and instead it is used for just about any carrier offering. The problem is that we connect to the Internet by repurposing these offerings and more broadband is very different from more "Internet". In fact, it is just the opposite because we get a faster subscription connection but not more coverage.

The phone companies also found refuge in cellular telephony because they could offer all sorts of new phone services with little worry about competition from others. But even in the domain of "mobile" all the traffic is going to bits and the cellular infrastructure is not well suited for carrying bits. And now the carriers are building yet another infrastructure for wireless bits in parallel with their existing wired infrastructure.

Once people realize that bits are bits and that there is no difference between wired and wireless bits we could quickly add capacity at little cost simply by providing access points along existing wired paths. They key is to shift the funding model to infrastructure so that access is available without any complicated arrangements. And that is happening. This is not "muni-Wi-Fi" as a billable service but basic infrastructure. Cities like Brookline MA are experimenting.

Imagine if New York City provided access everywhere even at low speed so that all sorts of municipal services and emergency works would take advantage of a common infrastructure. While one can make an effort to restrict use to approved devices and applications it makes far more sense to put that effort into adding sufficient capacity to serve all comers.

How can a carrier make money if it has no value to add above undifferentiated commodity bits? The value is no longer in the network. Cable companies are shifting their assets out of the network but old line phone companies have fewer options and little time. The question is when will investors view owning a network as a liability and demand new policies.

To understand the carriers' dilemma we can look at the harm that FiOS is doing to Verizon in allowing it to design systems that work only for FiOS customers. I'm very aware because I replaced the router provided by Verizon with one that works far better but that means I cannot use many of their services.

This dependence is not necessary. For now if I want to watch HBO on my computer or phone I need a subscription to a cable provider. That's like having to buy a piece of plastic in order to prove that I am allowed to listen to bits (that is, 0's and 1's) that represent music. This will change carriers will be forced to decide what business they are in.

For now network providers seem necessary but once we realize that they are not we'll recognize the symptoms of an industry whose time has passed.

Acting Locally

Once you've placed your bits on the common medium they are able to reach any device anywhere in the world with no further action. (OK, that's not quite true today but it's a matter of new protocols using the existing infrastructure).

The hard part is geographic – assuring coverage in a given area. The good news is that this makes it easier to identify a community which benefits from its own efforts while sharing among neighbors. Passersby would also benefit from presumed reciprocity.

For this to work the reciprocity must be implicit rather than relying on complex schemes that mimic the carriers' old business model.

As with home networking the big draw is sharing web access but the value is much higher.

Today there are devices that use common protocols to share video, operate devices and provide capabilities such as printing over IP. The value will increase rapidly as we explore new possibilities and as device architecture learn to take advantage of the power of ambient connectivity so that their device can simply work anywhere.

A medical monitor that "just works" everywhere is far more valuable than one that only works in special places and only if there are prior arrangements and payments.

New capabilities like a video doorbell with a touch screen interface that can also accommodate temporary access can be implemented with commodity devices and a small amount of software.

Installing home lighting without having to run wires between every combination of switch and fixture would save money. Interior decorators could move light switches or their successors at will.

Instead of having to install new devices just to save a little energy we can get far more creative approach. If you just want light and aren't picky a light switch can decide to open up a skylight instead of turning on a bulb.

This is a simple future in which we take advantage of new possibilities for what we do every day. After all, buying

books doesn't seem very high tech yet it has been transformed by technology. Instead of trying to tell stories about a future in which we have talking toasters we need just create the opportunity by having a common transport.

The Connected City

Cities need a common infrastructure for their own operation. Instead of building separate networks for each purpose we can have a common transport with abundant capacity. A fire engine should be able to receive a rich data feed as its racing to a fire and coordinate its operation with medical workers and others.

It's expensive to build a separate system for each purpose and it's important to be able to use any available path. This is especially true in an emergency. In fact today it is common to go to the nearest Radio Shack to buy Wi-Fi gear to use in an emergency because it's just too expensive and difficult to buy special gear.

A city is its people, not the buildings or the city government. Those institutions are there to serve its residents as well as the larger society. The residents aren't consumers of services, they are participants. Giving them the tools and information makes them contributors with a stake in a better city.

As we've seen, medical monitoring that works in the home should work anywhere in the city. In fact the ability to use such monitors must be considered a basic right and must not be compromised by requiring authentication or a billing relationship. This is a reason why it's standard for cell phones to provide for emergency calling. Why isn't the same courtesy extended to packets of data exchanged on the behalf of users (AKA people). The reason is that once you allow such bits to be exchanged you can't draw the line because unlike 9-1-1, the network can't know if bits are emergency bits without an elaborate mechanism that compromises the basic purpose.

Today's 9-1-1 emergency signaling is an interesting case because today's system harks back to the idea that you have to dial up "central" to place a call. It's unacceptable to have an emergency signaling which only works if someone is able to call and explain a problem and only if all the wires (or radios) and databases are just right.

Why aren't all fire detectors always connected (at least, if the residents choose) and provide rich information so you don't have to be home and awake to report an emergency? Sure there is a danger of false alarms but that danger is greatly reduced if we use modern technology instead of century old signaling systems.

9-1-1 signaling fails silently if there is a single missing wire whereas an IP based system can continually monitor the connectivity. Of course we want location information and need to provide such information as first class information rather than relying on direct line connections to a satellite. We can do this by providing information beacons while also letting people choose how much they want to reveal to others about their location.

The point here is not to design a successor to 9-1-1 but to hint at what is possible once we think outside the 19th century. In fact much of what goes through 9-1-1 can be done by direct relationships without burdening the city.

The 3-1-1 system has similar legacy problems not the least of which is that the idea of dialing 3-1-1 assumes that people's phone numbers are still geographic. We should be looking ahead to services less tied to the legacy of telephony and more associated with modern connectivity.

Greenfields and Federations

Greenfields or underserved communities offer an opportunity for a fresh start. Most underserved communities in the United States are likely to take a conservative approach and seek "broadband".

But groups of individuals can form their own connectivity coops. Imagine if instead of using the existing wires for DSL or paying a lot of money for new fiber they took advantage of the existing wires at essentially no cost and added capacity as needed without having the restrictions of billable paths.

In places where there is a funding agency such as the IMF we have an opportunity to fund infrastructure instead of extending a very high cost cellular model. The key is to understand the difference between providing opportunity and tying newly developing regions to a funding model they can't escape.

We also need to recognize that local connectivity is important -- it's not just about reaching a web somewhere out there.

The FCC

Alas, the FCC was created to maintain the current concept of telecommunications going back to the early history of the ICC (Interstate Commerce Commission) which regulated railroads and other such transport and the Federal Radio Commission that took the abundance of spectrum and divvied it up so as to create railroad tracks in the sky.

A connected society will have little need for the FCC to exist because the commons can be self-regulating. It is necessary to regulate a dysfunctional telecommunications industry because the business model was problematic even in the 1920's. Today there is an inherent conflict of interest in depending on the industry most threatened by a con-

nected future having the ability to limit connectivity because such limits are the only way they can create billable events.

An infrastructure approach is market-driven. Providers would vie to provide the best capabilities for the last money. That is real competition rather than the synthetic competition in today's broadband market.

The FCC has studied the idea of structural separation in which we have wholesale transport used by all content providers. But it's still a pipe-based approach. I've personally tried to get some interest in an infrastructure approach with a connectivity commons but the institutional knowledge is too deeply embedded in every aspect of the institution..

It would be nice if the FCC could provide guidance to communities in shifting the community phone companies (as well as WISPs) into being connectivity companies. But at this point the FCC may be too mired in the past. The best hope might be benign neglect rather than working to extend today's broadband. Instead it should act to rein in state legislatures which have passed laws against funding an infrastructure to carry bits because it is seen as unfair competition with the existing funding model. In effect they are legislating against the market process of reinvention in order to preserve synthetic competition.

And, in doing so, they have put a price on speech. We should honor the US First Amendment and reject the idea of a tax on speech.

Legal/Financial Path

Speaking of the US First Amendment, the entire edifice of the FCC rests on accepting a compromise made in order to license speech in the form of radio licenses. If it isn't necessary to restrict speech because there is no intrinsic scarcity how can we justify having what amounts to a Federal Speech Commission. It's not just that the word "communications" is a synonym for speech, but the commission actively manages ownership and control of content.

At very least today we understand, or at least understand, that the information and the bits are now distinct thanks to digital technology. More to the point, the FCC policies create scarcity and compromise our free speech rights in ways that cannot be justified in light of today's understanding.

The financial approach is to take a hard look at the business model of telecommunications. How is it sustainable if all the value is external and even with the control of the pipe the carriers can't prevent their users from bypassing them in buying services? How can we justify multiple physical infrastructures for broadband or cellular delivery once all the information is included in bits and there is no longer any differentiation? We have a natural¸ *local*, monopoly.

At very least investors should demand that the infrastructure (or network) business be separate from the content or services business so that they don't have to bear the cost of subsidizing facilities others get for free.

There is nothing secret about the carriers plight but investors and policymakers look away because they don't believe there is an alternative. But we know there is and not only that, it's an alternative that can drive rapid economic growth and improvement.

We should ask why communities don't own their own wires and facilities but must rely on third parties from far away in order to communicate within the community. We need to ask why we can't just pay for the wires once rather than paying rent forever. Why can't a city aggregate its purchasing instead of requiring each resident buy resale?

Once you take a hard look at telecommunications there is nothing to see! All we need to do is stop suspending our disbelief and stop trying to keep a failed business model alive.

Learning from Bits

The idea of infrastructure itself is not new – long ago societies figured out the importance of roads and postal system for facilitating commerce and communications. We also understand the importance of water, electricity and other basics without needing to justify each one for a particular purpose.

We tend to underappreciate the value of blank slates and fungible infrastructure in creating opportunity. Education and basic science are necessary for creating opportunity for what we cannot imagine.

Telecommunications focuses on giving us valuable solutions at a profit. We've seen how terrible this is for the future when we compare the telecommunications system that was the envy of the world to the Internet which is so much more.

Even though the Internet has been incredibly useful it still far short of what it can be. We have many efforts to create standards but very few are like the web. Most are limited to narrow purposes.

It's much harder to create common standards for cooperation. While the web itself has been a great success it's hard to share appointment data across applications and websites.

Something as simple as coordinating medical appointments becomes a major public health issue because we can't keep simple things simple and instead find funding for large all-or-nothing projects that tend to be expensive nothings.

We need more architectural thinking rather than trying to solve each problem in isolation. A common architecture is another version of the blank slate. We need to better understand the new building blocks and we need to understand the new literacy.

Epilog

The generativity of the Internet comes from decoupling two markets –exchanging bits and what we do with bits.

In a narrow sense it is about technology and the need for policies that allow us to take advantage of the new technologies without limiting it to the needs of the 19th century business of telecommunications.

Understanding this requires understanding the interplay of technology and markets along with an understanding of how systems (and markets) work and evolve without an intelligent designer. We need to avoid accepting the accidental properties of today's Internet and develop new protocols. The first step, however, is shifting the funding so that we can think outside the pipes.

In a larger sense the Internet is a laboratory for understanding how systems work. "Bits" is a very pure and abstract building block that doesn't exist out of context. But the lessons are far more widely applicable in understanding the interplay between context and building blocks.

With $3.7 Trillion dollars a year[ii] being spent on telecommunications services we will see a significant impact on the world economy merely by freeing up much of that money for more productive uses. The real value comes in what we do with the new opportunities.

Further Reading

Related Essays

I go into more detail on some of these topics in other essays:

- Thinking Outside the Pipe. This is the key to liberating ourselves from today's concept of telecommunications which assumes that we have companies that convey meaning rather than facilitating the movement of bits.
- Ambient Connectivity. A goal of an infrastructure approach is the ability that we can just connect without having to depend on providers.
- Zero Marginal Cost. This is closely related to the idea of ambient connectivity. What if we could assume there was no cost to exchanging bits?
- Internet Lost in Translation explains the disconnect between information and bits. For a deeper discussion read Information Vs. Telecom.
- ATT's Plight. ATT's attempt to merge with T-Mobile is driven by the fundamental problems with telecommunications a business model.
- Assuring Scarcity and Dumb pipes about the industries own public statements of how to protect themselves from the threat of abundance and how to keep from providing commodity connectivity, *i.e.* dumb pipes. The needs of business and society can be, and are, diametrically opposed.
- Purpose vs. Discovery. A key difference between telecommunications a shift from enumerated services to the opportunity to discover what is possible given the resources available.
- Spectrum as Farmland. Today's spectrum policy is locked into the metaphor takes the abundant capacity of wireless bits and treats it as just some more farmland to be auctioned off.
- Beyond Limits. An essay I wrote in 1997 that first explores the idea that decoupling markets is fundamental to enabling hypergrowth.
- Broadband Internet? Why broadband is the wrong framing.
- Twit TV Interview in which I respond to questions about Internet and infrastructure.

Others' Essays Books

- From Private Pikes to Public Roads. An essay by Profs Klein and Majewski.
- Railroaded: *The Transcontinentals and the Making of Modern America*. A detailed look at how the countries (western) railroad policies shaped today's America and, in particular, the telecommunications industry. It's not meant as a complete history but does provide useful insights.
- Science-Mart: Privatizing American Science. This is the blank slate problem applied to science. The shift from funding basic science (the seed corn of science) to trying to buy valuable results.
- The Rise of the Stupid Network. David Isenberg's classic essay on ATT's need to generalize their network.

[i] I'm not a lawyer so this is not only my personal opinion.
[ii] According to Plunkett Research.