Understanding Ambient Connectivity

Table of Contents

Introduction 1
Possibilities 1
Understanding the Internet 2
  Best Efforts 3
  19th Century law, 21st Century Issues 3
Ambient Connectivity 3
Achieving Ambient Connectivity 4
  The Funding Model 4
    Service Funding 4
    Infrastructure Funding 4
    Transition 5
    Same but different 5
  Understanding Connectivity 5
    Finding a Path 5
    Connecting Information 6
    Infrastructure for Infrastructure 6
    Actionable Information 7
  Governance and Society 7
    City Hall 7
    Sources of Unease 8
    We the People 9
How It Works 9
  Relationships 9
  GUID – Globally Unique ID 9
  GUIDs and Routing 11
Readings 11
Epilog 11

Introduction

If you walk around with a Wi-Fi analyzer on your smart phone you'll see we are awash in wireless capacity with even more wired (or fiber) capacity behind each access point. Yet we are limited to only paths made available by providers and only at the prices they decide to set.

The wires that we use for land line telephones can be re-purposed to carry tens if not hundreds of millions of bits each second using available technologies but we don't take advantage of the opportunity. Our roads and highways are full of unused and underutilized fiber.

If we look around we see abundant capacity all around us. We've taken our vast frontiers and fenced them in. We've taken our opportunities and put them up for auction to the highest bidder.

In the 19th Century we handed our ability to communicate to service providers – the telegraph operators. In the 21st century we can create our own solutions yet we are limited to the world of the 1800s.

We need to embrace big ideas that are changing our world:

- **Bits.** Digital systems are about bits. And bits are bits – all the same. It means we can take all the copper wires, fibers and radios and treat them all the same. We can create our own solutions rather than depending on service providers and centralized management.
- **Best Effort.** We can build very reliable systems out of unreliable components. This is another way we aren't dependent upon others. We can use very inexpensive "junk bits" rather than depending on expensive reliable bits. Best Efforts is counter intuitive – like vaccines our ability to deal with failures has made us stronger.
- **Relationships.** We can focus on relationships between two end points be they people or devices without worry about the complexities in the middle. This is also known as the end-to-end principles – we focus on the end points outside the network.

Possibilities

The Internet hints at future possibilities. Ambient Connectivity is a reformulation of the ideas in an attempt to understand and realize these possibilities. It should add at least hundreds of billions to the US economy each year and likely a lot more. More important, it would improve our quality of life.

Something as simple as a wristwatch that measures your pulse and reports irregularities directly to your physician could improve your life and reduce health care costs.

Knowing when the next bus is coming seems mundane but can make a big difference on a cold day. You can buy a $100 communicating GPS receiver and put it on the bus

but how does information get from the bus to you while you're waiting at the stop? Such tracking exists but it's the exception because it takes too much effort.

Rather than having to negotiate a deal for each application we need to be able to assume connectivity is just there – part of our ambient environment. At a technical level we can – it's just that it's made unavailable by business policies that date back to 19th century telegraphy when we financed scarce capacity by buying services.

The capacity is no longer scarce – it just seems that way because of these policies.

It's about basic rights. How can anyone "own the air" and how can companies own our very ability to communicate among ourselves?

It's about our economy and our lives. In the 1800's we paid telegraph companies and in return we got new possibilities and opportunities. Since then, thanks to digital technologies and the Internet we've moved on and now understand how to create our own solutions. We now understand how to share the copper wires, the newly laid fibers and the airwaves to communicate among ourselves.

This isn't just about communicating bits; it's also about using the computation capabilities we have. Problems such as security and access to information are not network problems. They are application problems.

Understanding the Internet

The Internet has been a great success. It has shown us how much we can do if we are free to focus on what we want to do rather than worrying about the details of wires and radios or even phone calls.

I remember when it was thrilling simply to read an Australian newspaper without waiting a week for it to show up at the Out of Town Newsstand. Today you can walk up to a browser anywhere, go to Amazon, buy something, and expect to see it at your home the next day. Or you can use the portable computing device in your pocket.

The Internet has liberated us from thinking about the network. Instead we can think about how to take advantage of connectivity. Yet public policy is focused entirely on the "pipes" we use to communicate and not about what we do with them – the applications.

At one time steam engines were big and clunky so you would have one in a factory and use belts and pulleys to bring the benefits to all the machines. It took a while before people realized that with electric motors you no longer need an elaborate system of belts and pulleys. Motors are now just a simple resource that we've even forgotten that once we used to have crank car windows open.

Today we have the idea that there is a big network in the center and we need to find the right belt or broadband to connect to it. Our local networks are like small motors – they do not need to connect to the one central network. They are valuable in their own right.

We're one shift short of a new paradigm for communicating and connecting systems.

A wristwatch that can report to your personal physician if your heart rate is too high should be a very simple application. You just assume a connection between the watch and your physician's office. In practice such an application is simply not worth doing. You have to negotiate a path either by making deals with carriers or hope you can make Bluetooth work so you can use a cellular phone that has the right data plan and even then it only works where there is a carrier signal. You then have to think about how to connect the data in the watch to actionable information.

In 1934, in the middle of the Great Depression we didn't trust markets so we took a socialist approach and turned ATT into a government regulated quasi-private company operating under strict control with a guaranteed rate of return. The FCC preempted normal marketplace mechanisms. We continue this tradition today with complex models in lieu of a market. I find it very disturbing that people defend the status quo in the name of the "Free Market".

We still act as if it is 1934 and take all this abundance and lock it into billable services because that's the business model that seemed to make sense then. Even if we have a subscription we still create billable events so we can surcharge our speech as if it we were using an antique telephone.

The providers have a rent-seeking business model which requires that they maintain control of resources forever and, in effect, hold them hostage.. A one inch strip across Main Street isn't worth much in itself but people will pay a lot to get past it. A copper wire isn't worth much in itself but people will pay a lot of money to use it to place phone calls.

We've already paid for the wires yet we can't use them because they are owned by service providers. They can't afford to simply give them away. That's like asking the railroads for free rides. We need a different funding or business model – one that isn't based on forcing us to buy rides or paying to communicate. It's a familiar model – funding common resources as infrastructure.

Verizon has deployed their new fiber (FiOS – Fiber Optic Service) and is trying to abandon this copper to preempt competition. With FiOS there is no phone wire yet they still charge me the very same price they did when they had a wire! Not a farthing less!

Best Efforts

The Internet is about an idea – "best efforts delivery". Normally if you mail a letter you expect the post office to do whatever it takes to deliver the letter. Networks packets are like letters and the traditional providers guarantee that they will deliver each one in order. This can be very expensive. The carriers take advantage of knowing that you are making a phone call or sending data so they can tune their service for the application.

With best efforts we take advantage of any available spare capacity. If a packet doesn't get delivered we can just resend it or simply treat it like a catalog that isn't delivered – no big deal. The nice thing about these junk packets is that they cost just about nothing. We just learned how to deal with lost packets and delays. We didn't have any guarantees but with no worries about costs we were free to discover what we could do with the new resource.

Things seem to come to a head when the Web threatened to overwhelm the capacity of the Internet. It turned out that demand created supply! It was easy to add more capacity as technology improved and because we didn't demand every packet make it through, just best efforts. We learned to be flexible in taking advantage of opportunities rather than having narrow requirements.

And as we got more capacity available we could even do voice over IP (VoIP) rather than paying a phone company to do it for us. All we needed was access to the same raw facilities that the phone company used. But we made it reliable on our terms rather than having to pay for services.

The carriers didn't even know the value of each bit because users decided what the bits meant. There are no video bits or phone bits or picture bits; just bits with no intrinsic meaning.

This is completely outside the very concept of telecommunications as a service industry. If they can't sell us services how can they make money? The only option is to use hostage pricing and withhold their capacity. That's why all the copper phone lines are purposely kept idle while billions are spent on new fiber. And even then we get only one percent or less of the fiber capacity.

Something is very wrong – 21st century connectivity has run smack dab into the needs of 19th century telegraphy. It's not just the hundreds of billions of dollars that go to pay for services that no longer make sense, like phone calls. The problem is that we're being limited in our very ability to communicate.

19th Century law, 21st Century Issues

Our rights of way were given to these carriers based on the 19th century notion that communications policy was like railroad policy. And even though we know that that is no longer true we cannot get back the free speech rights guaranteed us in the US Constitution.

We're also facing a legal system whose definition of anti-trust doesn't seem to have the concept that technology changes. The problem we have is not market share. The problem is control of a "value" chain and divvying up the marketplace among competitors firmly wedged in the 19th century. They use their control to prevent 21st century innovations. They can and do place a price hurdle on innovation. This is prior restraint and we cannot afford to be prisoners of ignorance.

This is not good vs. evil. It's simply the 19th century vs. the 21st century and we're all the worse for it.

We had a similar experience with shipping goods across the ocean. Loading and unloading cargo was very labor intensive with each kind of cargo being treated differently. Container shipping changed all this. Like packets each container is the same and can quickly be loaded and unloaded without regard to what is inside each container.

Old line shipping companies tried to prevent this change but couldn't since they were unable to control the ocean.

The FCC and its counterparts in every country in the world are managing telecommunications based on the 19th century idea of communications as a service. As a result we can't use our 21st century understanding to tap into the vast oceans of capacity. We can't even send radio signals without getting a license. Each radio frequency is like a color. Imagine a law that said you must register the color of your shirt in order to make sure that no two people in a stadium wore the same color. Yet that is precisely what spectrum policy is all about.[i]

Ambient Connectivity

Ambient Connectivity gives us access to the oceans of copper, fiber and radios that surround us. In the examples above our wristwatch can report our heart rate to our physician no matter where we are and no matter where the physician is.

This is a deceptively simple example. Indeed using connectivity is very simple but we need to dig deeper to understand the significance of Ambient Connectivity (AC).

We start with a simple statement of the problem: "I have a watch which can monitor my pulse and I want to share that information with my physician". We should be able to say this to the computer in just about those terms.

Isn't this something we can do with today's Internet? Sure, as long as:

- We have already paid for the path (subscribed).
- Are someplace already served by our particular provider. Typically at home or via a cell phone.
- We've got a watch that can communicate via Bluetooth to our phone and the user figured out how to set it up the particular relationship and you're using that particular phone.
- And the application developers
- Established a path between the end points even as they moved around or were behind firewalls.
- Took care of all the encryption and security requirement
- Matched the data in the watch to the requirements of the physician's system.
- There's a business model to justify all the costs involved.

OK, enough technical details. This is just to give you a sense of the many problems that need to be solved. It helps explain why such applications are not common even if they might save lives.

What is surprising is that today's efforts for "more Internet" by providing more "broadband" address essentially none of these problems!

Ambient Connectivity is a framework for addressing applications needs. The term "connectivity" subsumes "communications" and extends the concept to include "relationships" between pieces of information.

Achieving Ambient Connectivity

The Internet became what it is today by being a dynamic that gave everyone the opportunity contribute to its success while surviving the necessary missteps. Today's corporate web sites had their origins in individual experimenting with ideas without having to have a business plan. You don't need to have a complex justification for sending a few bits when there isn't any cost for those bits once you have a connection.

We can approach Ambient Connectivity in the same way by creating opportunity. We don't need to encourage innovation as much as remove the impediments.

The Funding Model

Service Funding

Telecommunications is a service industry. We pay companies for services like telegrams and TV. They maintain their own infrastructure in order to support these services. This worked very well in the 1800's.

And at first glance it seems to work well today. Once you've paid for your broadband connection you no longer need to think about the costs of using the Internet. Today you also have the option of a 3G data plan.

The problem with this model is that the Internet needs an ample supply of raw bits so we can create our own solutions. You can think of a bit as being like a kernel of corn. If farmers grow too much corn the price drops below cost. This is why we pay farmers to not grow corn in order to limit the supply.

This is why so much of the infrastructure we already have goes fallow. The telecom industry owns the facilities and limits availability of the bits so they are able to force us to buy their services. Cable TV operators use almost all the capacity of their infrastructure for their own services and give us only about one percent for "Internet".

This is understandable – they are acting rationally given their incentives. Services have high perceived value. It's a model that has worked for well over a century – at least for the carriers and service providers. Or, at least, it has until the Internet made the raw bits valuable.

Infrastructure Funding

Bits aren't really like kernels of corn, they are more like words. You may run out of red paint but you don't run out of the color red.

We can't say how many bits can pass through a wire any more than we can say how many words can fit on a page. We can keep making the type smaller and smaller if we are willing to use more and more powerful microscopes to read them.

The free market solution is simple – align incentives so people and companies can act in their own self-interest.

This seems like an ideal solution in which everyone wins. Instead of requiring scarcity we can find the abundance in what we already have. This is exactly what has happened with Moore's Law style hypergrowth for decades.

We don't need to manage all the details once the dynamics of the market are in tune with creating value. We can start very simple – using the existing infrastructure and protocols with a different funding model.

A city would typically hire companies to maintain and install infrastructure. It would award the contracts to those who can do the best job for the least cost.

A first step might be to "light up" the existing copper wires using technology which adapts to the wires as they are. Without the need to channel the bits into billable paths, all of the existing access points would be opened up to provide wireless coverage. I'll address some of the technical issues in a later section but they are secondary to aligning incentives.

Transition

Before we talk about transition it's important to emphasize that we are not "seizing assets". Any repurposing of carrier facilities will involve compensation or some quid pro quo. The problem is that it is hard to value the assets in the absence of a real marketplace. In fact since we're funding the infrastructure by selling services the carriers find themselves maintaining infrastructures for others. Verizon provides Vonage with a "free ride". Thus we could argue the infrastructure is a liability. Our goal, however, is to encourage transition and it is best to give shareholders an incentive to cooperate so that we can move on.

When we talk about the value of a network we need to ask "value to whom". Value is a measure that is only meaningful in context. The Internet has changed the market and the value to a network owner is very different from the value to society. And if the network value grows by a lot each time you add a node then we maximize the value by connecting everyone. If we divvy up our commons by having carriers manage each portion we're all the poorer for it. As a society we lose far more value than the carriers can possibly gain.

Our current legal system tends to favor the *status quo* and has difficulty resolving the inherent conflict of interest in having a service provider in control of the facilities that allow others to create competing services. In fact the FCC's mission has been to maintain the current service-based model because that's what seemed to make sense in 1934.

Yet the transition is happening despite the FCC's Regulatorium because it's simply too difficult to control the flow of bits. We are also becoming more adept at using the bits. Skype does a very good job even when the capacity is limited.

The recent Comcast/NBCU deal is interesting because of Comcast's efforts to expand their distribution to reach subscribers over IP (AKA, The Internet) even if they don't have a Comcast cable. I would be able to subscribe to Comcast using Verizon's FiOS only as a dumb pipe. And as we see the dumb pipe business is not sustainable.

In fact, as I write this ATT has requested to be relieved of its duty to maintain their copper infrastructure[ii]. This seems like an ideal opportunity to make a deal. We can make the raw copper infrastructure available as a community resource.

This is the real face of connectivity. To the extent that copper is locked into ATT's silo it hasn't much value and is a burden to ATT. But if it releases its grasp then the marketplace will quickly discover how much value can be found in the raw copper.

The question is whether we recognize these signs of transition or we redouble our efforts to maintain the status quo because it's easy to sell "more of the same". Thus we fight the market by creating artificial incentives for companies to invest in new billable paths (AKA broadband) rather than finding value in existing facilities. And these new broadband facilities remain woefully underutilized.

The solution lies in understanding Ambient Connectivity and why we don't need to continue the artifice of funding networking via the sales of services.

Same but different

It isn't necessary to fully understand Ambient Connectivity to appreciate the importance of aligning incentives.

We can look at a transition similar to ATT's 1984 divestiture. ATT wanted to get out of the retail telecom business and get into the lucrative computer business. We have a similar situation today as companies want to shift from being (dumb) pipe[iii] providers to selling services. It takes a different kind of company to do pure infrastructure and those already exist.

There are no guarantees. After all, in the end, ATT couldn't escape from the "pipe" business because they lacked the genes to get into the computer business. This is a stark warning for telecom shareholders – they can try to get ahead of the process or watch as the value of their investments continue to head to zero.

Understanding Connectivity

Finding a Path

If we go back to the example above we can understand that if the wrist monitor and the physician's system were near each other we could define the relationship using a wire.

As we see with the Ethernet you can put all the devices on the wire and define the relationship in terms of names or handles. You simply put an address on the message as if you were sending a letter via the post office. With Wi-Fi we don't really need to use the wire.

When you get home your monitor might hail (broadcast). But it will find no listener responding to the name (or handle) of the doctor's monitoring system. What it will find, on your home network, is a device that can offer to take the packets further.

It's simpler to think of this like driving – somewhere there is a doorway to the outside from your house. And beyond that is a sign pointing to the highway. If I'm in Boston I just need to find US-1 and I can get to Miami. The only complicated part is getting from my house to US-1 but I can find directions. It wouldn't be much more complicated to take US-1 to US-17 to get to a different city. I just need to know the address for the monitor and I can find my way there.

What makes this interesting is that US-1 isn't really a road. It's just a name we assign to make it easier to find our way.

You don't need to understand the all of the technical details but for those who want to. You can model networks in the same way. The Internet already interconnects local area networks but depends on a single backbone. We now understand how to interconnect these networks directly using the equivalent of route numbers rather than having a physical network.

This means we can fund local infrastructure locally and can choose regional funding if we want to have fibers that span the country.

If I'm walking down the street I can use any of the myriad access points and my messages can find a path to their destination. Anyone, the municipality or individuals can add capacity by providing additional access points.

It means I can start to tap into the abundance without having to make deals simply to send a handful of bits. I don't need a billing relationship or complicated protocols to connect my devices.

Connecting Information

Our focus on networks in themselves has diverted our attention from actually using information. We see this when we lose a hundred million dollars space probe because we confuse metric numbers with English (meters vs. yards). We need to connect information not just exchange bits.

This is a new frontier. Today even something as simple as synchronizing one's own address book across devices is problematic.

We should be putting in more effort to enable the use of computing and networks rather than simply focusing on the transport of bits. Those efforts have been counterproductive by forcing the bits into billable channels.

Imagine if we start to use the abundant information. Health care is just one example – even step along the way involves filling out forms and spending time on the phone authorizing events. When information is shared it is typically via large databases with mixed agendas. Why must prescriptions be processed by pharmaceutical companies with a vested interest in maximizing profit rather than empowering physicians who want to keep us healthy?

Infrastructure for Infrastructure

The Web is the visible face of the Internet yet as with cities much of what we rely upon is hidden from view. In our homes we define all the relationships with wires. To do something as simple as move a light switch you need an electrician to rewire the house.

If you share a driveway with your neighbor you can't simply give your neighbor permission to turn off the light if it's bothersome at night.

In the same way we have vast networks of wires running through our cities. Any change in policy and relationships is slow and expensive because it involves moving around the wires.

Imagine information being readily available. As in the example above, it wouldn't take much to add a GPS receiver and a transmitter to a bus. Its position would be available making it easy to produce an application that shows "next bus". Information is not consumed by being used. The same information can serve multiple purposes and needn't be channeled through a central service.

The current 9-1-1 system is very problematic. It only works if you have a phone line (or, perhaps, a cellular line). It requires every database be properly aligned and all you do is reach a 9-1-1 operator who requires you to explain the problem though there is the option of sending someone to the location associated with that phone number.

Your heart monitor would instead go directly to a physician. It could also be monitored by an emergency service. If your location were available it could be used to respond directly to you. Or if you're on a bus and a passenger tells the driver of your distress an ambulance can meet the bus or the bus can meet the ambulance. There are any number of policy options. And it's just that policy; you don't need a special system for each purpose.

Fire detection is another good example. Today's fire detectors might feep and, perhaps, get others in a home to feep but that's about it. Today's technologies allow richer information and the fire alarms can share information within the house and provide a more informed alert. They can also, if the homeowner chooses, send a direct alert to the

fire station telling where in the home a fire or other event is.

There are so many of these examples. The information becomes an available resource. It creates new opportunities for improving our life.

We've read about location based services for years but they have had limited impact because each one requires a business model and an expensive implementation. With ambient connectivity the barriers are far lower and can be implemented merely to improve our lives instead of having to sell us something.

Actionable Information

There is no sharp distinction between passive and active information. A phone number is passive until you mix it in with a telephone and it completes the call.

We've been using barcodes for decades. They are not self-describing – you have to look up in a separate database. More recently QR-Codes have given us self-describing ways to tag physical objects.

Self-contained information can be found on web pages. If you see a date for an event you should be able to put it on your calendar and share it with others. But the methods for doing this are still nascent.

We see a lot of emphasis on central databases but little on self-contained information. Your doctor writes a prescription on a piece of paper and then gives it to you to carry to the pharmacy. If he chooses to go electronic he passes the information to a "big pharma" database. The problem is this is funded by companies that use the data to gain marketing advantage. Why don't we have the ability to bundle up the information in a way that can be passed directly from the physician to the pharmacist? It could be sent electronically or using a method like QR codes with involving a third party.

Another version of this is all the data associated with my purchases. If I want a copy of my grocery list I should be able to get it directly from the grocery without having to pass the detailed information through the credit card companies. Instead the information could be linked to a transaction identifier (a handle).

The problem is similar to funding infrastructure. We need investment and research that transcends local profit motives.

We see this with financial data. Banks will present me with a picture of my financial information on their website but don't make it easy to manipulate the data myself. This benefits them by making the customers dependent upon the banks. They'll store an image of my checks on their computers but if I want an old check image I need to ask them to please print a copy for me. What happens long after the account has been closed? They might keep the information for a say seven years as per tax laws but what if I want the information for my own purpose and want to look at a ten year old check?

Fortunately I've got the skills to look at the information (HTML) beneath web pages and take the data for myself. This makes the web sites more generative than intended.

Counter to this trend is the "There's an app for that" approach. Unlike HTML web pages apps, be they standalone or Flash®, they don't make it easy to wrest control back.

This is why it's important to be explicit about connected information. We need to assure that the information (including information about physical objects) is available so we can build on it.

Governance and Society

City Hall

There's a general attitude that you can't rely on government to do anything right. This is understandable. But we're not asking the mayor to dig trenches nor we depending on the community to come out and dig up the street in front of each of their homes.

Just as we do with other services we'd hire people or companies that compete for contracts. Bits are simple so transparency will make it easier to compare offers.

Today's broadband networks were distributing television and are ill-suited for connecting communities. A Verizon customer trying to reach a Comcast customer next door may find the packets half-way across the country before returning – as I found when I did just that.

They are ill-suited to support vital infrastructure. You may wait days to get your connection restored and you have to abide by rules that limit how you can use the service. Cellular users have few options when they encounter dead spots.

With Ambient Connectivity your community government supports and manages the network. You can indeed petition city hall – after all if you can't get the Super Bowl the mayor won't get reelected. More important, perhaps, you're not limited to petitioning city hall. You can add your own capacity and extend the reach of connectivity to your basement even if the city isn't willing to do so.

Instead of worrying whether we can keep the bits flowing we should instead worry about whether the city is able to

take advantage of the new opportunities to provide services and save money.

Sources of Unease

We're living with the legacy of "Ma Bell" or "TPC – The Phone Company". It has left us with the implicit assumption of something called "telecom" policy with a regulatory apparatus for managing a national (and even international) infrastructure in which every element is critical.

As we've seen we can achieve far better results by aligning incentives decoupling infrastructure from services. Yet without someone in charge how can this work?

It's easy to understand the appeal of strong governance. When the Americans sought independence from the British in the 1700's many worried whether the country could survive … and we're still not sure.

We have plenty of examples of failure:

- **Municipal Wi-Fi**. These projects often have the same funding model as traditional telecom. They also tend to be more about the Web rather than basic infrastructure. Today's protocols also make it difficult for others to contribute capacity.
- **Bucket Brigade**. The bucket brigade model assumes people will use wireless relays in order to avoid any dependency on existing infrastructure. Given the constraints it's no surprise that these approaches offer limited capacity and long delays (latency).

The term "Tragedy of the Commons" invokes Malthusian fears that we'll exhaust finite resources. We also worry about "irresponsible" behavior as if there were a simple metric of good vs. bad. It might be irresponsible to exceed the speed limit unless we were rushing to the hospital. Then obeying the speed limit would be irresponsible. We need connectivity policies that don't depend on policing behavior.

We also worry about applications such as high definition video which seem to require guaranteed performance and capacity. They can be adversely affected by congestion.

The irony is that these problems are often the results of the current approach which creates chokepoints and our dependency upon providers. We've become inured to the word "provider" and forget that it is about our inability to provide for ourselves.

Somehow we seem to be more comfortable with the idea of a provider whose goal is to maximize profits rather than the local community which should have a common interest in our quality of life. Yet such fears have a real foundation in reality as we see municipal services being underfunded or mismanaged.

It may be necessary to set minimal standards as we do for infrastructure such as sewers but we first need to see real evidence of failure. Today we use only a small fraction of existing capacity because of a funding model that requires scarcity in order to force us into paying for services from providers.

We should look instead to the abundance of computing capacity as an indication of what is possible once we align incentives.

If anything we should be concerned about trying too hard to assure that bits will flow. Today's Internet protocols are transitional and any attempt to require that they operate in a certain way is more likely to create chokepoints than solve them. The same goes for concepts such as "responsible network management".

Closely related to the idea of "responsibility" is the presumption that we can and must put social policy into the network. While many of these concerns have more to do with imposed morality one can't dismiss all concerns. We just have to address social concerns as social policy not technical policy. A newsgroup that advocates violence is not inside the network – it's just an activity that uses the network. Or, to be precise, it uses the infrastructure to do networking.

We see a particularly problematic form in HIPAA which is designed to protect the privacy of our medical information. But it has become a corrupting force that subsumes all other considerations to prevent information, or knowledge, from escaping.

The reader may notice a theme here – the more you try to avoid risk the more risk you have. This is a deep philosophical issue about the limits of our ability to control the world.

We see this in the concern about emergency services as we try to reserve capacity for emergencies and provide special gear for predesignated emergency workers. The results can be tragic when we discover that such efforts leave us most vulnerable in an emergency.

We need to come to terms with the idea of resilience rather than assuring one but only one possible outcome. In an emergency it is the gear we can hobble together or buy at Radio Shack that enable all of us to become "emergency workers" at a moment's notice rather than depending on emergency "providers". It allows us to define new relationships rather than being confined to silos with police talking only to police and firefighters to firefighters.

There is no magic. If we want to be able to respond to an emergency in the third subbasement of a building we need to think ahead and have the ability to communicate as well as supplies like water. We can do this by making sure the particular location has connectivity and a water supply or by having a means of doing so as-needed.

We see the problem in the 9-1-1 system that is designed for emergencies only. Some cities have created a 3-1-1 system for information. But they are traditional systems dependent upon central point dispatching.

We need a more integrated approach. But I'm using the term "integrated" to mean the opposite. We need the ability to couple disparate solutions into a whole that emerges from the parts but is not imposed. The medical monitoring examples are part of the emergency response system in one sense but in another sense they are apart and independent.

We the People

We are so used to perceiving government as "them" that we forget about government as "us". As we see top-down governance is effective when we know the answer and just need to bring everything else into alignment. That was the theory in 1934 when we thought we understood communications and just had to make sure it was implemented right.

It is hard to get cooperation on complex systems. The Internet has shown us that we can greatly simplify the problem by framing it as enabling connectivity by normalizing the infrastructure to bits and accepting best efforts as sufficient.

In the traditional model of telecommunications as a service any attempt to contribute to the commons is treated as theft of service because we are indeed reducing the revenue of the service provider. With Ambient Connectivity we shift the model so that everyone can contribute.

There is still some dependency because we are using common resources and there is a risk that we may not provide sufficient capacity or availability. Given how easy it is to provide capacity and how simple it is we shouldn't let our problems with complex systems such as education and health care lead us to certain scarcity rather than just the risk of scarcity.

How It Works

Relationships

The Internet has given us something that seems magical – the ability to focus on what we want to do without being concerned about all the "stuff" between. If I want to look at a web page I just go there. If I have a GPS unit on a bus I can just connect to the unit and find the bus (with permission, of course).

If we aren't dependent upon service providers then we need to take responsibility for failures. If we can't get enough capacity for a normal voice messages we need to be creative. We can choose to give up or to find a way to gracefully degrade the speech or send it as a voice message or use text. The less we are beholden to promises and expectations the more ways we can succeed.

One version of this dependency is requiring "quality of service". If no one entity controls the network then we can't depend on QoS to guarantee we'll get the performance we want.

If you require such guarantees you'll find it very expensive to own all the wires along the path and will have to think very hard about whether you need them. You may be surprised at your own creativity.

Relationships are persistent. Unlike a phone call there is no wire – real or virtual. We can just take advantage of the relationships when we need to. It's "just there".

One way to simplify the management of relationships is to take complex descriptions like "the kid I sat behind in 4th grade" and reduce it to a simple handle – a big number. Where do these numbers come from? Same place children's names come from – we just make them up.

GUID – Globally Unique ID.

Very simple a GUID is a random number that we assume to be unique. We use it as a name but without the baggage of worrying about which John Smith. We don't even care if it refers to a person or a building or a piece of paper.

Handles are a basic mechanism we use to take advantage of the opportunities for ambient connectivity.

The GUID is a deceptively simple concept. The simplicity is deception. Behind the simplicity lies a very rich concept with deep philosophical implications.

How do you know two things are the same? How do we work "with" something without the thing itself?

If I have two cars that look the same I can use the VIN or Vehicle Identification Number to tell which is which and find the records for each one. A central authority issues the pools of VIN numbers to each car manufacturer which then assigns cars numbers from that pool.

You can think of the VIN as a handle for the car. You use the handle to represent the car in a database. You may start

with a description like “the red car in the showroom” and then “convert” the description into the VIN.

For many purposes we can think of the VIN as the car. You can find out a lot about the car using the VIN. You can buy and sell it (with proof of ownership). It’s similar to saying that http://frankston.com **is** my web site.

We could get into deep philosophical questions such as what happens when we take the parts from two cars to put together a composite car. What should the VIN be? We don’t need to answer such questions – the VIN is a mechanism. What you decide to do with it is your choice. In this case you decide whether it’s a new car or one of the component cars reincarnated. Or you may have multiple handles.

The handle is a number and in itself nothing more. An actual VIN may have letters but in the computer it’s just a big number. It may be help to think of it as just a series of 1’s and 0’s – a long series. We don’t really use it as a number – just as a handle.

Well, not quite. The VIN actually encodes a lot of information in the number. To be more precise the VIN has a semantic part which provides some information about the car and a part that is just the arbitrary sequence number assigned to vehicle. It is this part, the vehicle number that represents the individual car.

All we really need is the unique part. We can get the rest by using that identifier as a database key though we can keep the self-descriptive information locally for convenience.

If I want to keep my personal database of cars then I can I just keep a list of these handles.

What happens when we build our own car in the back yard? Do we need to register it with a central authority just to to make sure it’s unique?

That’s where GUIDs come in. Instead of a using sequential numbers we choose a random number. If there were 1000 cars and we used a number from one to a thousand then we have to be careful to avoid reusing a number. We call that a collision. If we chose a number between one and one million it’s less likely we’d have a collision. In practice we use numbers that are much longer and with half a billion cars out there we choose a very long number.

With a long enough number the odds of having a collision are the same as being struck by lightning while being hit by a meteor. This means we don’t need a central authority to hand out identifiers. It’s only recently with computers that we’ve needed and been able to work with GUIDs.

GUIDs are just numbers so they don’t have intrinsic meaning. You can’t tell whether 123181 is a VIN or postal code of the garage.

I can understand the appeal of hierarchical systems like Bob.Frankston.Com but we pile too many irreconcilable agendas on one mechanism.

We need to heed the lessons from the evolution of databases over the last 40 years. Early databases were hierarchical but we found that linking using abstract identifiers or handles gave us flexibility to rapidly evolve database technologies. More important is that we could reorganize information as our understanding of that information improved.

The key is to associate context with the identifier. In a sense this rebuilds the hierarchy from the edge in keeping with the basic design concept of the Internet. But that’s a topic in its own right.

Handles are just number so we use the same mechanisms no matter what the data is. We look up a VIN number just like we might look up a driver’s license number. It’s just a mechanism and doesn’t build in implicit policy.

Instead we must make the policies explicit. We need to be careful – explicit doesn’t mean rigid. We need to preserve the social ambiguities. Again, we’re talking about mechanism and we can include “maybe” in our vocabulary.

A special kind of identifier is a capability which is just what it seems to be. I may have a capability (or permission) to turn a light on. A pragmatic version of this is abstracting the modern car keys which just act as identifying tokens. With wireless entry you just exchange bits. Why not store multiple capability handles in a virtual key ring? You can then simply enumerate the cars you have access to in one device rather than having to carry a pocket full of physical tokens.

This is another blurring of the distinction between descriptive and active information. The capability can be an additional handle for the car but one that comes with privileges. But we can also make the capability more abstract and have it open any car in a given parking lot during working hours. We’re only limited by our imagination.

Skype shows us another facet of defining relationships in terms of a pair of identifiers. The relationship always “exists”. Unlike traditional phone calls the relationship is completely outside any network. It only consumes resources when bits are actually exchanged. This allows a far richer set of relationships.

Of necessity I can only touch upon the very rich concepts of abstract identifiers or GUIDs. In fact focusing on the GUID is an arbitrary way of looking at this concept.

GUIDs and Routing

It's useful to drill down on one aspect of GUIDs – how to get a message to another party using a GUID. I won't go into all the details or possibilities – just enough to give a general idea of how such a process may work.

Because the GUIDs are flat – this means a handle (the use of the GUID) is universally unique. So no matter how I get to you if the handles match it is you. This is an oversimplification since if we really want that to be true we need to guard against spoofing using methods such as digital signing but let's keep things simple.

If the other end point is nearby we could just yell out the name or the handle. What does this mean? Today if you are on a local area network you use ARP (Address Resolution Protocol). Very simply this means you broadcast the name (typically the IP address) of the other system and it responds with its MAC address.

GUID handles are little simpler – we just broadcast the handle and if we get a response the other system is nearby.

We can use the same technique with radios – just broadcast a message with the other system' handle and if it "hears" the signal it can answer. Of course this means we must have compatible signaling. In an old style system we would be listening on a hailing frequency. Things become more interesting if we could use the other party's handle as the key for the waveform. It simple recognizes its name and picks up the signal. Since there is an endless supply of GUIDs the parties would generate a new one for the particular conversation.

Things get more interesting if the other end point isn't nearby. You'd then need some hint for how to find it. This would be a handle for a third party who can help us. We could also encode explicit hints in that handle.

The process is recursive but it ends when we reach a "well-known" identifier (a synonym for handle). In effect we are mapping a name (the basic handle) with an address (where the end point is).

Well-known identifiers are useful for generic hailing. For example we could ask for any nearby system that knows how to take a packet further. For a home network it would offer to take the packet out into the larger world. Once we get into the larger world we can use the kind of sign posts we see on the road system to take us to our destination.

What makes this interesting is that we reuse the handles within the routing system itself with the waypoints using them to communicate among themselves.

Readings

These are at http://frankston.com/public (AKA http://方思腾.com).

- An introduction to Ambient Connectivity. It includes the video of a talk I gave at Stanford University Sept 23, 2009.
- Purpose vs. Discover– A look at the subtle issue of purpose vs. discovery.
- Spectrum as Dirt – Creating scarcity through spectrum policy.
- Assuring Scarcity – Scarcity as a necessity for supporting the current funding model.
- Copper, Fiber and Radios – Thinking in terms of Copper, Fiber and Radios rather than services.
- Opportunity for innovation.
- The Broadband Internet?
- Beyond Limits – How decoupling enables hypergrowth.
- Demystifying Networking – Why we don't need nor can tolerate providers.

Yes, there are multiple names for the site. I have a short name for the same reason that others use bit.ly but I avoid that point of failure (which is blocked in China). The Chinese name is because, well, because I can).

Epilog

The Pony Express lasted from April 1860 to "October 26, 1861, two days after the transcontinental telegraph reached Salt Lake City". We've lived in the age the telegraph for one and a half centuries.

Ambient Connectivity is an entirely different concept but due to the happenstance of history we find our abundant landscape walled in by telegraph's legacy. Time to take down the walls.

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[i] For more on "spectrum" see http://rmf.vc/SD.UAC.
[ii] ATT is still using parts of their copper infrastructure but Verizon, with FiOS is going all fiber.
[iii] The term "dumb pipe" refers to carrying bits without adding value. Thus you can't profit from the use of the bits.