Fiber-to-the-Home (FTTH) Costs Are Now In!

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Early in 1979 I was penning the final conclusions of my Ph.D. thesis as the culmination of nearly four years of work investigating the ultimate telecom transmission capabilities of copper cables. Needless to say, by 1980 I was hard at work on optical fiber! My key Ph.D. conclusion was that copper was dead in the water and untenable for the demands of the latter part of the 20th century and beyond. Repeater spacings were already down to 2.2 km, and further upgrades of transmission capacity would see that reduce progressively to 1.1 km, 0.5 km, and lower.

Beyond the basic loss and bandwidth constraints of a copper technology going back some 100 years or so, there were additional limiting problems such as: crosstalk, random and periodic reflections, water ingress, installation distortions, and general degradation that made copper untenable. In contrast, 1980 saw optical fiber making rapid progress with bit rates and repeater spans well in excess of copper.

Fast forward to 1986 and I was leading a team responsible for engineering aspects of the first optical fiber cable spanning the Atlantic. In just six years we had gone from no lasers, no pin detectors, no chips, no SAWs, no fiber, and no cable to a fully deployed cable with 280 Mbit/s on four fibers giving a capacity of 560 Mbit/s each way. At the same time experimental results on terrestrial routes had seen speeds well in excess of 1 Gbit/s over 100 km achieved.

During that same year of 1986 my team also demonstrated fiber-to-the-home (FTTH) at a lower installation and operating cost than copper. It was just one of those brilliant years that come along with one world-class result after another. For my company (BT) the future was clear—we just had to get fiber out there. The accumulation of evidence was so overwhelming, there was little discussion; the Chairman of the day (Sir George Jefferson) gave the "Just Do It" order.

By 1990 BT had largely replaced all the copper in the long lines network with fiber, while at the same time being well advanced in the digital upgrade of the core network. Phenomenal improvements in performance and economics were recorded as company staff numbers shrank from 242 000 to 110 000 without any strike action or enforced redundancies. It transformed the company!

So what happened to the local loop, and what could it possibly cost during the mid-1980s? Well, as a postgraduate student I attended a broad selection of courses beyond engineering and science on the basis that I would most likely have to manage people, money, and projects at some time in my life. Among these courses was one on accounting and economics. Here I learned about discounted cash flow, net present value, and most valuable of all, whole life costing. This was more useful than I could have ever imagined!

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As I started to look at the local loop problem I was surprised to find people accounting on a very limited basis. Not only where their base numbers dubious, the accounting models left a lot to be desired. So I had a go and went far beyond the upfront and depreciation models of the day. I included the following all-encompassing aspects:

1) ***Water ingress*** in copper cables accounts for 50% of faults in the local loop. The cost of repair and keeping cables dry is enormous in materials, manpower and revenue losses. Fiber on the other hand can be wet—glass is impervious to water.
2) ***People*** employed in the local loop switch and hub sites to reroute copper pairs, and repair all manner of faults, inflict a further 25% (or so!) line and switch faults. With fiber, rerouting can be remotely programmed and human intervention at a physical level is not required, which saves around 95% of all human activity in the networking aspects.
3) ***Fiber reach*** is well over ten times that of copper and therefore removes huge amounts of electronics from the field as well as reducing the number of switch and hub sites required. For example: in a copper network with 1000 switch sites, the move to optical fiber would see a reduction to only ten or so. The continual saving on unwanted real estate and the upfront—one off sale—recoups vast amounts of money.
4) ***Frames and patch panels*** in switch sites and the local loop are eradicated along with the need for manual changes and the attendant reliability risks.
5) ***Truck fleet*** and truck rolls are dramatically reduced along with the need for civil engineering—generally below 10% of the copper equivalent.
6) ***Energy*** consumption is vastly reduced with fiber, along with huge reductions in the need of battery back up, standby generators, and access points.
7) ***Recovering*** the old copper cables realizes a thick seam of copper, lead, and plastic for recycling. Here the cost of disposal is much less than the cost of recovery and a good profit can be made.
8) ***Empty ducts*** and other facilities open the door to new and radical business models in concert with the needs of ISPs and OLOs plus MetroNets.
9) ***Operational and business support*** systems can be dramatically reduced (by > 90%) in scale as the amount of plant to be managed with fiber compared to copper is reduced by around a hundredfold depending on the network geography, topology, operations, and services delivered.
10) ***People*** requirements for a fiber network are < 10% of the copper equivalent.
11) ***Path transparency*** of fiber networks gives a very effective future proofing against new technologies, services, and customer demand. In short, fiber gives us the ultimate and near infinite bit transport pipe. Unlike copper, it does not suffer from bandwidth restrictions, harsh attenuation and crosstalk limits at high frequencies, and is indifferent to signal format.
12) ***Operational expenditure (OPEX)*** falls year-on-year with technology advances and new, and unlimited, service offerings.
13) ***Future technology*** coming down the optical and microtechnology pike just boosts all of the above arguments further and further, decade on decade, and even in 1986, I could see the prospect of network people requirements falling to 5% or less of those still employed today.

Well, that's most of the arguments I used in 1986, and not only were they right at that time, they are even more right today! The advent of optical amplifiers, plus lower loss fibers, lower cost devices, IP, and the WWW really have vindicated the original economic arguments.

I am not a religious man, but if I was I would be tempted to think that God is a communications engineer as he gave us abundant supplies of silica (for glass) and silicon (for chips). Both are inert and safe, easy to manipulate and work with, and have ideal electrical and optical characteristics for computing and telecoms. Unfortunately, mankind discovered copper first and went off on a very expensive detour!

I jest of course, for without copper technologies we would never have discovered the magic of silica and silicon. But now the time of copper is long gone and we should have gracefully bid farewell in the 1990s for sure! We should be starting with a clean sheet of paper and be mapping where we want to be.

So, what went wrong?

It wasn't as if the U.K. had gone it alone with fiber deployment in the long lines arena. And certainly we were not alone in our investigations in, and need to roll out in the local loop. Country after country across the developed world were independently coming to the same conclusions. It was as if the economics of the mad house kicked in globally! People seem to have forgotten all they had learned in their economics classes, and the whole emphasis

flipped to a simple-minded up-front costing model. It was as if the whole industry lost the plot overnight!

To be fair, the guardians of the copper access network had seen their long-line brethren retired early or found new jobs as their numbers shrank by 90% with the advance of fiber, and naturally enough, the promise of DSL technology seemed to significantly discount the need for fiber in the short and long time. But in the outturn DSL delivered < 10% of what was originally (and outrageously) promised in the early 1990s, and the customer appetite for bandwidth grew 1000% faster than the forecasts! But all that was predicted too, but largely discounted because it was economically and politically unpopular. The planet had decided that copper was "it" and no amount of proof or rationalizing, or reasoning, was going to change the decisions made and directions already selected.

Of course, the reality was a bit more sophisticated and brutal. In the U.K. case BT had built factories to manufacture the electrooptic components and systems to supply the needs of the local loop. But the impending fiber rollout went against the beliefs and needs of both government and regulators of the day who favored local loop unbundling and market liberalization. And so, top down, the program was stopped dead in its tracks and the factories were soon sold on.

What a bummer! Failure had been snatched from the arms of victory, and as they say: the rest is now history. But the decision to stay with copper in the access network has, to date, cost most nations an arm and a leg. But what is particularly damaging is the apparent and continued inability to make any intermediate correction of what was a really bad decision in the first place. Worse, it seems as if all economic decisions are now exclusively made on the basis of up-front cost. What really fascinates me is that the people taking such a simple minded view inside a company wax lyrical about the quality of their latest and exclusively designed goods. They take a lifetime view at home and a cheapest-is-best approach to everything for their company!

Earlier this year I attended my first optical technology conference in a decade and the biggest nonissue being extensively discussed was still FTTH. But the advances in optical fiber, lasers, devices, and microprocessors over the past 20 years have rendered all the arguments for FTTH absolutely unassailable. However, the cheapest-is-best merchants persist, only now they add the WiFi and WiMax clause. What they don't now understand is that more wireless also means more fiber!

Those who grasped the nettle and extended fiber to home and office in Asia have achieved vast and continuing savings, plus growing markets, while those in the West hanging onto their copper past continue to fight to survive against untenable operating costs and crippling bandwidth limitations. And, unfortunately, they continue to ask the dumbest of questions:

> "Why do people want all this bandwidth and what are they going to do with it?"

Imagine what would have happened if our Victorian forefathers had adopted the simple-minded, soda straw, one-at-a-time issue, economic principles of today. There would be no telecommunications network or WWW! I do hear, however, the canal owners looked at the railway train and also asked a really dumb question:

> "Why would coal want to travel at 100 km/h?" ■