Internet 50 Keynote Transcript: "A History of the Technology that Powers the Internet"

Presented by Kevin Kimberlin, Chairman, Spencer Trask & Co. // UCLA Samueli School of Engineering // Oct. 2019

Thank you for that introduction. I'm grateful to be here with you all today. And Spencer Trask & Co. is grateful to be a partner for UCLA's 50th Anniversary celebration of the first Internet communications sponsored by Internet hero Professor Leonard Kleinrock.

I, myself, am an entrepreneur and have been at the forefront of some of the great scientific advancements of our time, one of which was fed by Kleinrock's work, and, as I began to think about this 50th celebration, I thought, such a great opportunity to highlight some of the technological advances, and some unsung heroes, that make the conversations today and tomorrow even possible.

Most of us remember the mid 90s when you got your first email address; what about additional functionality like instant messaging; facebook, napster, search, and then boom -- the Internet was everywhere!

How did we get here so quickly? One of the most amazing stories at the root of the Internet revolves around the laser and, as it happens, the laser is celebrating its 60th anniversary of discovery. It is such a foundational technology that, without it, we would not have the Internet and communications infrastructure we do today. Its discovery is a tale that leads directly into all of the great history, and most certainly the future, that you will explore today at this conference and hear about tomorrow, if you attend the 50th Anniversary event.

It's my favorite kind of story and the reason I started Spencer Trask & Co. It's a story of an entrepreneur, an innovator, a committed student and visionary, and an unsung hero. Has anyone in the room heard of Gordon Gould? Or perhaps Theodore Maiman...he's a local?

It is a classic east coast - west coast tug of war. The work of some of the great scientific minds of our times working feverishly to effectively capture and control light. It's the work of a UCLA alum and a student at Columbia University - and it has changed the lives of every single person in this room forever.

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THE STORY

The reason for studying the past isn't so we can wax nostalgically, it is so we can use it as a basis for predicting the future.

This story starts about one hundred years ago when AE published his thoughts on the Quantum Theory of Radiation — how matter and light interact. Specifically, he expanded his dialog with Max Planck on how atoms absorb and emit light, part of a thought process that , with input from Schrodinger, Hiesenberg and others, gave rise to Quantum Mechanics, what NTT Physicist Shochai Sudo has called "the most successful theory yet devised by the human mind."

He explained in his 1917 Quantum Theory article two forms of emission:

First, there's the **spontaneous** one we see from the sun, from the fires around LA today...from the light Bulb that we may or may not see in various parts of California.

Second, he realized something that was inconceivable and is still pretty hard to understand and that is how light could be created by stimulated emission. Remarkable because stimulated light is not found anywhere in the Natural world, at least not on Earth. (Quasars). Perhaps stimulated emission is an entirely man-made conception, the relationship between a photon knocking an excited electron down to its less excited state to release another photon of the same wavelength and direction as the first. One photon in, two photons out. The equivalence captured in his formula E=mc2, "c" being the speed of light. He explained all this, yet even he was so perplexed, he wrote "For the rest of my life, I will reflect on what light is."

It took a lot of reflecting to glean something of value from this insight. In fact, 40 years passed before someone figured out how to make stimulated light. That happened on November 13, 1957, Columbia University student Gordon Gould invented the laser. Gordon Gould was a hard-drinking, heavy smoker with conmunist tendencies and a communist girlfriend.

One author, Nick Taylor, tells the story. He said: "The insight, when it came, struck Gould with the force of a revolution. It was a Saturday night. He sat up in bed, marveling at its perfection.

Like all good solutions, it was simple and obvious, once you thought of it. It had been there all along, waiting to be seen for what it was." (Taylor p66)

Light Amplification by Stimulated Emission of Radiation. The LASER. In his journal on that invention, he described communications as one of the applications for his Optically Pumped Laser Amplifier.

On April 6, 1959, Gould filed a patent for his laser.

Thinking that he needed a working model to patent his invention, he left Columbia and applied to ARPA for support, the source of Kleinrock's IMP work as well. But his communist ties came back to haunt him. The U.S. government refused to let him work on his own invention. This delay allowed his rival Theodore Maiman to jump ahead of Gould.

But Maiman could not generate enough power to optically pump his chosen lasing material -- a red ruby crystal cylinder.

Here is where a recent UCLA graduate came to the rescue.

Charles Asawa, born to Japanese immigrants, became the man of the family at age 13. During WWII, he was sent to a Relocation Camp in Arkansas and in 1943, he was released and joined the US Army. After the war, he was one of 400 translators sent to Japan under Douglas McArthur.

Then he returned to UCLA where he earned his degree in spectroscopy and went to work for Theodore Maiman at Hughes Research Labs.

Knowing about his struggle to find a powerful source of light for the devise, Asawa suggested a photographic FlashLamp from a professional camera. On May 16, 1960, they coiled it around a cylinder of Ruby and then set off the flash. It worked!

That first laser produced 10,000 watts for a millionth of a second.

Meanwhile, on the other side of the country, Gordon Gould had the fight of his life on his hands.

To pay the rent during his war, Gould pursued optical telecommunications by co-founding the aptly named Optelecom. Inc.

His first contract put a video sensor on the end of an optical fiber to carry a laser signal for the US Army Missile Command. It was a pioneering optical networking system.

Low-loss fiber optic cable had been demonstrated by Corning but not yet manufactured at scale, so Optelecom was forced to hand-spin its own fiber by using torches fueled by hydrogen tanks in the basement of Gould's employee — while his children slept upstairs!

Yet, soon enough, their product line included "systems and devices that rely on the interactions between light and matter such as lasers and optical devices used for optical amplification and wave mixing." That idea became known as Wave Division Multiplexing, or WDM.

Gould brought Dr. David R. Huber to Optelecom to work on this and other projects in 1983.

Huber wanted to multiply the number of usable lanes of optical fiber which led him to invent a tunable, in-fiber amplifier based on the erbium-doped fiber amplifier, derived from inventions by David Payne and deServier.

Now, this is where I have the privilege of coming on the scene. One of my early ventures was apartnership with Dave Huber, and that venture enabled me to be part of another important moment in Internet history that was actually fueled by Professor Kleinrock's work. We co-founded a company that was the first to commercialize a dense wave division multiplexer. Not very exciting as a standalone statement, so to give it some context, it was this wave division multiplexer that changed communication for the rest of the human race. The explosion of the data superhighway...the capacity of fiber optics carrying our data from device to device, every day. It made global what Kleinrock made possible.

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So, back to the story...Optelecom CEO, William Culver introduced Huber and this project to me. Impressed with its potential, I jumped right in and on November 13, 1993 — exactly 36 years to the day after Gould's inventions of the laser and the optical amplifier, Optelecom, Huber and I chartered a new venture to build a complete optical networking system.

We started to unleash the 99.9% unused capacity of fiber, "permit full utilization of the "data superhighway" and lead the "paradigm shift in communications."

Ciena Corp. made and deployed the first dense WDM system in mid 1996, based on our dual-stage optical amplifier. By switching, routing and restoring, all in the optical domain, it required much less power than electronic telecommunications systems. Most importantly, the technology made 16 lanes out of the formerly one lane highway. But that was just the beginning. Further advances led to 100 channel, 1000 channel and, with innumerable advances in fiber quality, lasers, amplifiers and chip processing. Recently, for example, in Australia on Telstra's Melbourne optical network, Ciena and Ericsson rolled out a system that delivers the equal to 1.2 million 4K high-def videos over a fiber pair, simultaneously. Yet, I will tell you, we are still nowhere near the full utilization of the 'data superhighway."

Because of this enormous bandwidth, WDM became the common basis of all metro, regional, national, international and intercontinental oceanic communications networks. And this all started at Columbia University.

Where are these light amplification-powered networks taking us in the Future?

Not all on fiber. Musk and Facebook and Google are taking lasers into space because nothing beats light—its speed, purity, immortality and its quantum nature are unsurpassable. This, just as it underlies much of what we do, it is the key to our future.

Data center interconnects, AI work loads, virtual reality, telepresence, holograms, will all depend on optical amplification.

Furthermore, optical computing, and optical and quantum cryptography will harden our networks to give us personal and professional security.

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CONCLUSION

So there you have it...unsung heroes and a largely untold story of the laser.

My firm, Spencer Trask & Co., is all about Big Ideas. Mr. Spencer Trask's Light Bulb and Electricity Network—lit up the 20th Century. If there is one thing I've learned it's that you never know where the next big idea will come from. We know that UCLA hails great minds, as we've seen in Charles Asawa and Professor Kleinrock. Perhaps the next great mind is sitting in your classroom or working in the lab next door. Pay attention and don't lose sight of an opportunity to make a real change.

Whether it's the story of the Internet or some other innovative greatness, there is always some kind of fight or struggle to keep advancing it to the world stage. It's not for the faint at heart. And if you're that entrepreneur, keep at it! Much like the heroes in this story of the Internet, the best ideas and the spirited entrepreneur will prevail. I've seen enough from UCLA and I will be keeping a sharp eye on this University.

Thank you. And enjoy your day.