Sue Nelson
Just for level purposes, if you would give me your name and title please.

Vint Cerf
Oh, this is the dominion network of the Canadian broad-corp-in-castration.

Sue Nelson
Hello, I'm Sue Nelson and thanks for joining me on Create the Future a podcast brought to you by the Queen Elizabeth Prize for Engineering. Vint Cerf has been Google's Vice President and Chief Internet Evangelist since 2005. But his achievements and fame predates and surpasses even those rather awesome titles. One of the so-called Fathers of the internet, he was among the winners of the inaugural Queen Elizabeth Prize for Engineering in 2013, for his work on the Internet and the World wide web. Thank you, Vint. Let's start with that rather amazing title. I can't let it pass. Chief Internet Evangelist. What does that mean?

Vint Cerf
Well, first of all, we were making it up as we go along. Second, I didn't ask for that title. In fact, when they asked me what title I wanted, I said Archduke. But Larry and Eric and Sergei went away and came back and they said, you know, the previous Archduke was Ferdinand, and he was assassinated in 1914. And it started World War One. Maybe that's a bad title to have. Why don't you be our Chief Internet Evangelist. Now, I must correct one thing for you. And that is that my work was on the Internet. But Tim Berners-Lee is the one who invented the World wide web.

Sue Nelson
The prize though sort of incorporated all of you didn't it?

Vint Cerf
Yes. Yes, it did. But you were introducing me and not the other four people who received that honour.

Sue Nelson
I said, “among the winners”, is that allowed?

Vint Cerf
Oh I see, I didn't hear that.

Sue Nelson
So I'm okay then am I, off the hook?

Vint Cerf
Okay, fair enough.

Sue Nelson
So, what does it involve? Do you go around being enthusiastic? Because you are quite an enthusiastic person and you're not averse to having a bit of fun.

Vint Cerf
Oh, of course not. I mean, what's life if you can have fun with it? I think a sense of humour, frankly, is essential for survival, especially in these days.

Sue Nelson
So, that amazing title again, you go around enthusing? Evangelising?

Vint Cerf
It is evangelizing but people wonder if it's a religious title and I tell them I'm geek orthodox. But the honest effort is to get more internet built around the world. I mean, even now, as we speak in 2020, only slightly over 50% of the world is online right now. And I would like to get everybody the opportunity to be online. I don't want to force anyone online. And we have lots of reasons why people might resist going online for a number of concerns which I hope we are talking about later, but it is essential to go around and get government policy set in such a way that it will attract more internet implementation. There has to be investment in infrastructure, transmission facilities, whether it's optical fibre, or cable or radio, 4G and 5G, and so on all those things you needed in order to support internet protocols and the transfer of data to support the World wide web. So, I go around trying to convince lots of people, whether it's in the private sector or in the public sector, government, to adopt policies, plans, procedures, practices, to help increase the accessibility of the internet.

Sue Nelson
Now somebody like myself who uses the internet every single day, multiple times a day, it's a part of my life. What do you see as the benefits for the rest of the world who perhaps, you know, are approaching the internet for the first time other than, you know, becoming obsessively checking social media or using it as a research tool?

Vint Cerf
Well, we could talk about whether that's a good thing or a bad thing. The good part is the enormous access to content of the internet, which, of course, is quite varied. And so companies like mine, Google have as one of their primary objectives, the ability to uncover for people the best quality information we can find, which is why we index billions of pages of the world wide web and we try to rank order them when someone does a search to produce the best quality information, matching what we believe they're looking for. So, my view right now is that the internet is an enormously useful tool and some of the variations that Google has introduced include translations, so sometimes the information you're looking for is in a language that you don't speak, we can automatically translate from one language into your preferred one. In my case, that would be English, but for other people it might be French or German or Russian or Chinese or something else. And so, we use artificial intelligence tools, primarily machine learning, in order to accomplish that objective. Keep in mind that we are indexing all content in all languages and that, of course, is a huge benefit for people who are trying to find out answers to questions that they have. Of course, Google has added other applications as well, electronic mail being a very popular one and more recently, the Google Cloud Service, which was essentially computational services so that companies and individuals who need the power of computing and they need it to expand on demand, go to companies like Google and others, to get access to that capability so they can build their own applications, possibly for themselves and possibly as tools for other people to use. So, there's this rich environment of computation and application that the intranet supports. And so, from the beneficial point of view, it's a wide-open space. I mean, it's almost as if software is an endless frontier, you can do almost anything you want to if you can figure out how to program it.

Sue Nelson
Now you're a mathematician to begin with, a degree in maths, PhD in computer science and yet the Queen Elizabeth Prize, I think, probably surprised a lot of people in that it made some for the first time think of the architecture of something we use every day as an engineering success.

Vint Cerf

Well, and indeed, it is an engineering success. And I consider myself, although I am trained as a computer scientist, I like to build things and I like people to use what I build and so there's a synergy between the computer science side, which is the theory behind packet switching, which is what animates the basic internet structure. And then there's the practical side, which is building something which is affordable, which is reliable, which is secure, which we have some work to do on, and which provides a platform on top of which new applications can be built. And so, all of that takes serious engineering, especially when you think about it - it's global in scope, it has to work in every country in the world, it has to work in different languages. By good fortune, the parts that I was responsible for, my colleagues didn't worry too much about language because everything was in binary bits, zeros and ones. Language becomes something which is up in the application space, and my protocols TCP and IP, don't notice anything about that. It's other people like Sir Tim Berners-Lee, who's another one of the recipients of that inaugural prize, who did the application layer work that creates the world wide web.

Sue Nelson
So let's go into what you did because I think people are familiar with IP, TCP perhaps not so much, but they're never entirely sure what it actually means, even when you actually explain what it stands for.

Vint Cerf
So well, we should start with that. First of all, the internet's architecture is a layered architecture, there were a series of different protocols layered on top of each other and the lower ones supporting the functionality of the upper ones. Second thing to realize is that that concept arose out of an earlier network, which was built with the support of the Defence Advanced Research Projects Agency in the US. That was called the ARPANET, which stood for Advanced Research Projects Agency Networks, surprisingly, and it had a component here in the UK. One of the nodes of the ARPANET was installed in July or so of 1973 at University College London in the laboratory of Professor Peter Kirstein. So sadly, Peter passed away in the age of 86 last January of this year, 2020, but had a long history of connection with networking. Not only with the ARPANET but also with the subsequent internet. So, the Internet Protocol layer is easily understood if you know anything about postcards.

Sue Nelson
Postcards?

Vint Cerf
Postcards. You think about them as if they were electronic postcards for a moment. The Internet packets have a 'To' address a 'From' address and some content, which is similar to a postcard. The to address, of course, is where it's supposed to go. And when you think about what you do with a postcard in the postal world, you put it into a post box and you assume the post office will eventually deliver it to the destination, and you've no idea by what route it might go and you don't care. You also know however, that the post office is not 100% guaranteed. So sometimes if you put a postcard into the post box, it doesn't come out at all. This is also true of internet packets, you can put them into the internet, sometimes they don't come back out again, these are called best efforts systems. The second thing that you know is that if you put two postcards into the post box addressed to the same destination, there's no guarantee they come out in the same order you put them in. This is also true of internet packets, when you put two of them in, one after the other to the same place, they may come out in the other order. Third thing that the internet does that the post office doesn't do sometimes, is to duplicate packets. So, if you put one packet into the system, two may come out the other end. The reason for that is if one of them gets lost or appears to have been lost and gets retransmitted, it's possible that it didn't really get lost. It's just one of the parties thought it was lost so it sent a second copy to recover from that and then two of them show up at the other end. So, you might wonder why would anybody want to use a system that loses things, gets them out of order and possibly duplicates them? And the answer is because that's the

simplest and easiest way to build this lowest layer of the architecture. In order to correct for all those deficiencies, we put another layer of protocol on call Transmission Control Protocol. And the best way to understand that is to imagine your task as if you were sending a book to a friend through a postal service that only carried postcards. So, you can't give them the book. What you can do is cut the pages out of the book, cut them up, so they fit on the postcards, and then you realize that not all the pages have page numbers because you cut them up. So, you literally write down numbers on each postcard 1234567 in sequence, so that your friend on receipt of the disorderly postcards can put them back in order or can recognize that there's a missing postcard. So now you've got all these postcards that you've pasted the pages of the book on. Now you have the problem remembering that they might get lost, so you keep copies in case you have to send duplicates. Then you wonder, how do I know whether my friend has gotten the postcards that I've sent? And so you get this brilliant idea that he or she should send you a postcard saying, I got everything up to postcard number 420. Then you realize that postcard might get lost. So, then you say, “what do I do then?”. And the answer is, well, you look at your watch. And if you haven't heard anything from your friend for a while, you start sending duplicates until you finally do get a postcard telling you what the state of affairs is on your friend side. Then you start thinking about one other possibility, suppose you had 1000 page book and you cut it up into 2000 postcards and you took it down to the post office and by a miracle, all 2000 of the postcards get delivered to your friends’ post box on the same day at the same time, except they don't fit because the post box only holds 200 postcards, so the other 1800 blow away or the dog chews them up. So you decide, okay, I have to have a deal with my friend that I won't send more than 200 postcards at a time until I actually hear whether he or she got those 200 before I send the next batch, that's called flow control. That's how TCP works. It does the flow control, duplicate detection, retransmission and reordering. So those two protocols create a uniform and sequence stream of postcards going from the source to the destination. And then we build on top of that, all the rest of the internet, including the world wide web.

Sue Nelson
That's amazing, I'm not sure I could repeat what you just said but that made it understandable, but also made me realize how logical it was and I can see why you'd need a mathematical, very logical brain to do each set.

Vint Cerf
Well, in fact, much of the design of the internet is a consequence of thinking logically about the constraints on the problem and then deriving solutions which were almost obvious as you understand the constraints that require you to do certain things to overcome deficiencies in the system.

Sue Nelson
Was this a whole when you while you were at DARPA, the US Department of Defence Advanced Research Projects Agency, what made you leave DARPA?

Vint Cerf
Well, I was at DARPA from 1976 to 1982. Prior to that, I was at Stanford University working on the internet design with my colleague, Robert Kahn, who by that time had gone to DARPA himself from another company called Bolt Beranek Newman, which built the underlying packet switches of the ARPANET. So, I had four years at Stanford, then I came to DARPA for another six years and in an earlier incarnation, I was at UCLA working on my PhD, but also working on the ARPANET project. So, I’d had quite a few years working on this DARPA sponsored network research and around late 1982, I had two sons and I started calculating how much it was going to cost for them to go to college and concluded that I might not be able to do that on a government salary. And so, I joined the private sector, specifically a company called MCI where I was asked to help them build a digital post office, which we could easily translate into an email service, but it was a commercial email service. It was called MCI mail. So, I went to work for MCI as the Vice President of the Digital Information

Services Company, built MCI mail, and over a period of about four years got that into operation within nine months of our initial work. It was a really wonderful, intense, nine-month period, and then additions were made over a period of several years. As it became a more operational system with less development required, I decided to return to the research world and join my colleague Robert Kahn as he left DARPA and started a company called the Corporation for National Research Initiatives. We spent eight years together exploring applications of the internet, digital libraries and a variety of knowledge, robots and all kinds of other national information, infrastructure, concepts and applications for about eight years.

Sue Nelson
It sounds as if you've had this, obsession I was going to use, but maybe passion is a greater word, or maybe a mix of both, that you've stuck with something throughout all those different jobs?

Vint Cerf
Maybe it's because I can't do more than one at a time and so I tried to turn everything into one project. The fact is that I have been working on that kind of networking, or had been working on it since 1968 or so at UCLA and all the way through my years at Stanford, and then the years at DARPA. And even after I left DARPA, I was still working on this in the application space, and by the time I left the research operation at the Corporation for National Research Initiatives, I was back in MCI putting them in the internet business and I stayed there until 2005. I then join Google, which is also in the internet business. So, I've been fixated on internet ever since 1968, which, we can do the math now is, holy moly, about 32 years, no 42 years, 52 years? Can it really be 52 years?

Sue Nelson
Yes, it would! If it was 1970 it would be 50, plus two for the 68, 52 years.

Vint Cerf
Yeah. Holy moly. That's a long time!

Sue Nelson
Time flies when you're having fun and you've obviously been having fun. I mean, you look like somebody who loves their work.

Vint Cerf
I don't think anyone should be forced to work on something they don't enjoy. But I've been very fortunate. Some people aren't. For me, every job I've ever had is always been a source of great fun, interest, challenge and learning.

Sue Nelson
I was surprised to discover that you've been a visiting scientist at NASA JPL, the Jet Propulsion Laboratory. What did you do there?

Vint Cerf
Well, around 1998 I joined the team at JPL to start designing an interplanetary extension of the internet. We had just seen the Pathfinder project land successfully on Mars in 1997. The previous successful landings were in 1976, with the two Viking landers, and then nothing worked for about 20 years, things crashed and burned or missed the planet. But finally, we got a success in the Pathfinder landing and so the team that I started working with was trying to figure out how we could we build a more rich communications environment to support manned and robotic space exploration instead of just focusing on point to point radio links.

Sue Nelson
Which has a massive delay?

Vint Cerf
Well, that delay, we can't erase that. The speed of light and the distances between the planets is what determines what the latency is, what the delay is, and we can't change that. On the other hand, we could have a richer communications environment with alternate paths to recover from various kinds of failure. And so, we started designing this interplanetary internet. And I thought we could use the TCP IP protocols to do this because it worked on Earth. So why wouldn't it work on Mars, and I'm sure it would work on Mars. The problem is between the planets, the distances are significant. They're literally astronomical. So even when we're closest together, Earth and Mars are 35 million miles apart, which means that a radio signal at the speed of light still takes three and a half minutes to get to Mars. And of course, another three and a half minutes to come back and when we're farthest apart in our orbits it's 20 minutes one way and 40 minutes round trip time. TCP IP was not designed with a 40-minute round trip time in mind. So we had to develop what we called a delay-and disruption-tolerant networking protocol suite, which we now call the bundle protocol, because bundle and packet sound about the same, but bundles are for interplanetary communication. So those protocols that now not only been designed, built, tested but also standardized by the Consultative Committee and Space Data Systems, which is a UN agency made up of all the spacefaring nations who are agreeing on what protocol should be in space in order to support manned and robotic space exploration. So we have ESA, we have JAXA in Japan, we have NASA in the US we have the Korean Space Agency and others who are participating in the development and deployment of these interplanetary protocols.

Sue Nelson
Which will be incredibly useful not necessarily planetary, but with the Artemis program and NASA returning to the moon with talks of a permanent settlement on there at some stage, possibly resource mining, that actually this is something that would be incredibly useful.

Vint Cerf
Well that's right and in 2024 we're expecting to launch the Gateway, which is an eccentric orbit spacecraft that goes close to the earth and also close to the moon. Kind of like a space elevator because you jump onboard the spacecraft. When it's close to Earth, you ride it to the moon and you take the shuttle down to the moon, you do what you have to do, you take the shuttle back up, and then ride the gateway all the way around to Earth and then shuttle back down to earth again. So we're going to use the interplanetary protocols in that are in that mission and other subsequent missions in preparation for the missions to Mars, which are still to come.

Sue Nelson
That's amazing. So, no slowing down then it's still work, work, work?

Vint Cerf
Why would I want to slow down? I have these 900 mile an hour theory. Once you get up to 900 miles an hour, don't slow down or stop because you'll just fall over. So I just keep going.

Sue Nelson
You're very, I have to sort of describe the way you're dressed because it's incredibly dapper. It's a grey pinstripe suit with a matching waistcoat, a paisley burgundy tie and a rather fetching, what looks like a red silk scarf in your top, in your breast pocket. Are you always smartly dressed? I'd read that you were, but I thought no, he can't always make or maybe you do.

Vint Cerf
This is trademark. I've been wearing three-pieces pocket squares and the whole bit for 44 years and there's a simple explanation for all this. I was at Stanford doing the internet work when DARPA asked if I would come and run the program. And my wife who was from Wichita, Kansas, announced that if we were going to Washington DC, I should be wearing three-piece suits. Now, she knew that I enjoyed being well dressed anyway. I had not got the three-piece suit habit until she went and bought three three-piece suits at Saks Fifth Avenue at Stanford Shopping Center in 1976. So, we went across the country carrying my three-piece suits. I went to work at DARPA and one of the three suits that she had acquired used Seersucker because she knew that it was going to be hot and humid during the summer months. So, I ended up wearing those suits at RFM?. One day I was called to testify before one of the committees in our Congress and I was wearing that Seersucker outfit and I did my testimony and I came back and you know, nothing happened, we went on with our business. And then a few weeks later, the director of DARPA asked to come and ask me to come to his office to discuss my testimony. And I was very fearful that I had messed up somehow, and he was about to fire me, and it was the end of my government career. So, when I walked into his office, he had a letter from the Committee Chairman. And he said, Well, the Committee Chairman says, thank you very much for your testimony, by the way, he's the best dressed guy from DARPA we've ever seen. And I took that as positive feedback and so I've been wearing three pieces ever since.

Sue Nelson
Absolutely. Well, it's funny you should say Seersucker, I've not heard that word in a long time. It's an amazing material and it is cool.

Vint Cerf
It's very cool. I have two Seersucker suits that I use for the summertime.

Sue Nelson
Now you mentioned your wife and I'd read that she had been deaf for a long period of time due to spinal meningitis. And you know, at the start of this podcast, and I was teasing you about "no I have written it right" and you didn't quite hear - you also have some loss of hearing, how did that happen?

Vint Cerf
Well, we don't know for sure, but I was six weeks premature in 1943 and back in those days, they didn't know what else to do but put me into an oxygen tent to make sure that my, as yet, immature lungs would get enough oxygen into the body. So, the speculation is that it started as sensory neural loss which has been continuous over time. So, I lose about a dB a year, so at my age, I'm about 75 dB down. On the other hand, I've been wearing hearing aids ever since I was 13. And the hearing aids have gotten better. Even as my hearing has gotten worse.

Sue Nelson
I can't even notice them.

Vint Cerf
Well they're just little hearing aids inside the ear. Now in my wife's case, she lost her hearing when she was three. And it was abrupt and complete. She became profoundly deaf in 1946. And she learned to lip read and spend about 50 years simply lip reading her way through life, which is amazing. She went to high school and elementary school and college and raised two sons without hearing anything. And then in 1996, at the age of 53, 50 years after she lost her hearing, she went to Johns Hopkins University in Baltimore, where she had a cochlear implant for the first time. She learned about the cochlear implant on the internet, which is sort of a nice irony. And that was an extremely successful operation, about 20 minutes after she went back there to

Johns Hopkins to have the speech processor activated, she picked up the phone and call me. We'd been married for 30 years and hadn't been able to use the phone, so that was a pretty dramatic moment for us. By the time I got home, I couldn't get her off the phone. She was, you know, anybody who called she wanted to talk to.

Sue Nelson
There's an immediate benefit of the internet in having knowledge at your fingertips. What would you say is its biggest potential? Because there's more I assume.

Vint Cerf
Well, first of all, if you think about it as a facility for computer communication, you really have an endless potential array of applications. Again, it's simply a matter of figuring out how to program them. And so, connecting computers together for various and sundry purposes is a dramatic aspect of internet and it's gotten even more dramatic now that we can do it with radio links. So that they don't have to be physically tied with wires. Now, Bob and I were doing mobile packet radio in the early and mid 1970s and also packet satellite which are both radio based. That was deliberately done in order to find a way to use this technology for command and control and we knew that it had to work in airplanes and ships at sea, and mobile vehicles in the original ARPANET was based on dedicated telephone circuits. So, the radio aspect of internet has been with us literally from the beginning. What's more interesting in today's world is that mobiles are also part of the internet and that was a fortuitous confluence when the iPhone arrived in 2007, thanks to Apple and Steve Jobs, it immediately made these two technologies mutually reinforcing. The mobile phone, the smartphone made the internet more accessible and the internet made the smartphone more useful because it had access to all the applications on the internet. And of course, the smartphone itself has literally millions of applications that have been written for it. And you can see how dependent people have become, you and I included because there are many apps that we run all the time. We use it for communication, we use it to look things up, we use it to play music, we use it to watch videos, sometimes those are entertainment, sometimes it's learning how to do something. So, the benefits will continue to extend as we get more sensor systems in place for safety and security for health monitoring, for environmental monitoring. In fact, eventually for self-driving cars, for smart cities, all of that is drivable out of the basic internet infrastructure. But perhaps the most important thing and also the biggest challenge, is this is a platform which is filled with vast quantities of information contributed by the world's inhabitants. Unfortunately, not all of them are capable of, or choose to offer the best quality information. And so, we have misinformation, some of it by accident, some of it deliberate and disinformation and wide ranges of utility in the content that we find on the net. And so, if there's a challenge here, it's figuring out how to find good quality information on the net, how to inhibit bad behaviours and harmful behaviours using that internet infrastructure. So that occupies a great deal more of my time now than it did in the early days of internet when we were just trying to get it to work.

Sue Nelson
I mean, that's one of the big issues and conversations that's being had at moment, isn't it? Is the ethics involved. I mean, where do you stand on that? Do you think it should be absolutely totally free at the point of use or, or that maybe it should have, as in say certain countries like China, more state control In terms of what you can and can't watch. I mean, I know myself, I get really angry, this is more social media I think, but you do a search for a certain term and then all of a sudden, you see porn?

Vint Cerf
Well, I don't know what terms you're searching for, so maybe we shouldn't go there.

Sue Nelson

BBC, which trust me that has a double meaning you don't want to know about.

Vint Cerf
Well, that is a big problem. Language is a big problem in general, because people repurpose terminology. Several things occur to me. First of all, when Google indexes the worldwide web, it's not trying to exercise value judgment during the indexing process. But when you do a search for something, one of the things we try to do is to rank order the responses in in order of utility in response to what we think you're looking for. We typically try to evaluate the websites, for example, there's a 160-page book, which we use to train about 10,000 people to do manual evaluation of some of the websites. And then once we have got the sample set of websites that have been evaluated by those raters, then we use their evaluations in order to train a machine learning system so that we can run it against all the other millions or billions of pages.

Sue Nelson
So that's equivalent of trusted sources, is that it?

Vint Cerf
Well, yes. Although, our definition of quality is what counts here. What makes a web page useful? If it's just a set of links, for example, we call that a link farm. We don't consider that to be useful, generally speaking. If it never changes its content, we don't consider that to be useful. If it's useful website, it should be bringing new content to your attention. So, the rank ordering of a response to a search is informed by their ranking rating which we have been able to apply to the web pages we've encountered based on the machine learning training that we've done.

Sue Nelson
Isn't that still subjective to what a certain group of people might decide is the right ranking? Because there are certain news organizations, for instance, that give more accurate news than others. But would they still have the same ranking?

Vint Cerf
Well, I want you to be very careful about how you ask that question. Because the criteria by which we do the evaluation of a web page is not based on a subjective opinion about the content as much as it is the quality of the webpage itself. Now, there are other reasons why we might end up ranking some websites and sources more highly than others. But one possibility is that more web pages point to that one, and it's an indication that it's viewed as more useful and more valuable than others. That's called the PageRank algorithm. That was the original mechanism by which we rank ordered pages, PageRank. Since that time, that was 20 years ago, we have several hundred different indicators that tell us something about quality, one of which is the source of the of the information. And as you say, what typically happens is the people who do the training or create the training set are more likely to train or to rate things like, you know, Financial Times higher than some other publication.

Sue Nelson
Than a tabloid say?

Vint Cerf
Or say. So there is, I would say an indirect recognition of quality sources based on the way in which these things are being rated in addition to which the sites that are more frequently referenced often are indicative of the utility of the content. Now the sad thing about all this is that once anybody knows about the specifics of these rating systems, they can try to game the system. So, as an example, in the early days of the Google

system, since the pages that were pointed to more, were rated more highly, people would go build a bunch of webpages that point to a poor-quality page in order to increase its apparent utility. So, then we have to figure out in some more automated way, whether that's what's going on, whether there's a bunch of useless pages that just happen to point to this destination. So, we have this constant tussle, we alter the evaluation criteria and the results that come back, we see whether people click on the first second, third, fourth, fifth response that we've given and if everybody clicks on the second one, instead of the first one, it tells us that maybe the first one is not a very good quality response, and that causes the system to be adjusted for that. So, there's a variety of tools that allow us to respond, we hope in the most useful way.

Sue Nelson
One issue that's very big at the moment is cyber security. Do you see this as a game of constant catch up? Are the cyber hackers always one step ahead, or do you feel that, on the other side in the same way that people learn how to game the system, so you're the one who's trying to always be one step ahead?

Vint Cerf
Well, in the security space, it's a huge challenge, because the hacker only has to find one hole to exploit, whereas the defender has to plug all the holes. So, in that sense, you're always a bit behind the hackers. The way to get ahead of that, of course, is to try to write software that doesn't have bugs, because if it doesn't have bugs, that probably means you can't explain the system. Unless of course, it's a bad design in the first place. I mean, an example of a really bad design would be a device like a webcam that has either no access control at all or has a well-known username and password for control. In which case in either of those two cases, somebody who is roaming around on the net looking for webcams could simply cease a bunch of them. And somebody did a few years ago and created a botnet that had about 500,000 devices in it. They're all webcams and they cause the webcams, because there was no access control, to send their megabit per second streams to the same target a company called Dyn Corporation. That's a 500 gigabit per second stream of data hitting that company's website knocked it over. And that was a very dramatic demonstration of why you need to design systems that have access control built in from the get-go. So secure by design is a really important philosophy.

Sue Nelson
And you've won all sorts of awards throughout your career. I like the fact that you cross several presidents because you've won the US National Medal of Technology from President Clinton, the Presidential Medal of Freedom from George Bush, and appointed to the National Science Board, which is an honour in itself, I think, by President Obama. To me, it shows the sort of cross politics as well, in terms of what you do.

Vint Cerf
Well, keep in mind that I moved to Washington in 1976. So, I have worked with every administration, including Carter, all the way up to the present and trying to be as apolitical as I could. Although, I will admit to you in my older years, I have become somewhat more partisan.

Sue Nelson
What do you do to relax?

Vint Cerf
I am an inveterate reader. I enjoy reading history and biography. I'm a nut for science fiction and I like things like Tolkien. In fact, I would read Tolkien and repeat it once a year at least, because the language is so magnificent. And my wife I enjoy watching films, especially if they're captioned so that we can actually understand the dialogue. By good fortune, most everything is captioned these days, especially if it's a

streaming video of some kind. So, we're subscribers to things like Netflix and YouTube and Amazon Prime and all those other things.

Sue Nelson
I loved, I'm a bit of a Star Trek fan, so I was really impressed that you'd been technical advisor to a Gene Roddenberry production Earth: Final Conflict, which I'm embarrassed to say, I've never actually seen, but how did you get involved in that?

Vint Cerf
This was a really interesting story. When I was at MCI, was a senior VP for engineering and the public relations team rented an auditorium in Los Angeles, and sold tickets and then told me that I was now meant to go and entertain people for two hours. They didn't tell me ahead of time. And so I was a little upset about that and I said, well, I'm only going to do this if you can get me on to the sound stages at Paramount where they were Shooting Star Trek films and television shows, thinking they'd never be able to do that. Except one of the PR people used to be Tom Cruise's PR person and she knew everybody and got me into Paramount. So, I spent a half a day running around in all the Star Trek sets. While I was there, I ran into Majel Roddenberry, Gene Roddenberry's widow and she started telling me about the various television shows that she had discovered manuscripts for in Gene's office, which she hadn't gone into for six or seven years. Finally, she found manuscripts for Earth: Final Conflict and Andromeda. So, she started a production company called Lost Script Productions and they started shooting up in Toronto, and one of the other producers who was with me, Joel, at the time said, "well, why don't you be an advisor for the show?", and I said, "hey, happy to do that!" and then they said, "well, why don't you just come on the show and play one of the characters", so I became the president's chief of staff for Earth: Final Conflict, and I only had one scene in one episode. But they were very sweet about it. I had my own trailer with a little star on it.

Sue Nelson
That's great!

Vint Cerf
And it was the speaking part, which I understand is a big deal. So, I had a great time.

Sue Nelson
Do you ever get inspiration from science fiction? Do you ever see some and think "yeah, actually, I could apply that, or I could take that, or I could make that happen"?

Vint Cerf
Well, frankly, yes. I mean, science fiction is usually about, especially nuts and bolts science fiction, which starts with known physics and then extrapolates, it really makes you think, well, what might be possible or what's in the way of doing something like that? So, for me, science fiction and science fiction writers are great stimulants for thinking about what might be possible.

Sue Nelson
Now, the Queen Elizabeth Prize is well established now. What are your memories of receiving the award and going to Buckingham Palace?

Vint Cerf

Well, first of all, I remember hearing the report on the radio, which was absolutely fantastic. All I could think of was, “the engineers won!”. And I remember reading a book called Longitude, which is all about the Harrison family...

Sue Nelson
Dava Sobel.

Vint Cerf
They were trying to build a ship's chronometer and there was a £10,000 prize way back, I guess, in the 1700s, which was a lot of money. But the Astronomer Royal at the time didn't think that the chronometer guy should win, he thought that the navigation ought to be done by the stars. And so, he made it harder and harder for them to win the prize. It was three generations of the family worked on those things, and in the end, they did win. And so that that was my first reaction. The engineers won this time, the engineers won the Queen Elizabeth Prize for Engineering. So that was really a wonderful feeling. And then coming here to London was wonderful because my wife by that time had a terrible case of Downton Abbey disease and we'd already spent a month the year before in 2012, roaming around looking at 37 stately homes and manor houses, including Highclere where it was filmed. So then I'm thinking, well, we moved here for six months, we arrived in June just as the Queen Elizabeth Prize ceremonies were undertaken and so we met the Queen, two Princesses of the Realm, the Prime Minister, the Deputy Prime Minister, and I'm sitting here thinking, and it’s a £200,000 prize out of the million pounds that I shared with my four colleagues. And I'm thinking well, it's all downhill after that. Not the case because a few weeks later I got an email, asking whether my wife would like to come and spend the day on the Downton Abbey set with the cast and crew. And so, from her point of view, the high point of our six months was Highclere.

Sue Nelson
That's brilliant though. Do you spend much time in Silicon Valley? I can't imagine you with the guys with the hoodies and the you know, the women looking all trendy and what have you in your three-piece suit.

Vint Cerf
I am a 19th century guy and a 21st century world I wear my three-piece suit when I'm out in Silicon Valley, at Google even though the Google dress code tends to be fairly relaxed. I do have a disguise however; I have a baseball cap into which has been a sewed a grey ponytail. And I wear that in order to distract from the fact that I'm still wearing the three-piece suit.

Sue Nelson
Do you see the internet as a human right effectively, that everyone on this planet should have access, in the same way as say 100 years ago it would be to clean water and fresh clean air?

Vint Cerf
Even today, let alone 100 years ago, clean water and fresh air is something we all hope for. Human rights are very special things, clothing, shelter and food, things like that. I don't think internet as a technology is a right that we can guarantee. However, the right to communicate, the right to get access to information, the right to share information, is very fundamental to our society and certainly to democratic societies. To the extent that the internet assists in that and enables that. It enables the right to communicate. If you had access to the internet and someone took that away, that would be a violation of your rights. The thing that disturbs me about asserting that internet is a human right or should be human right is that it is just a technology and eventually it will be replaced by something else. And so, we wouldn't want the endowment to internet as a human right to become a kind of an odd confusion when something better comes along. How should we react to the previous

assertion that the internet was a human right? What is this new thing? So, I would much prefer to focus on the fundamental right to communicate, to share information and get access to it, and to make sure that the technologies that enable that are available, regardless of what those technologies are.

Sue Nelson
And what would you say has been the driving force throughout your life and your interests? What has been spark? Where do you think it's come from or how would you define it?

Vint Cerf
I think this is the essence of engineering, it is the desire to design and build things that other people can use. There's nothing more satisfying to an engineer than to be given a problem to solve and to have the solution be useful to other people. Those are two really wonderful incentives for being an engineer.

Sue Nelson
it doesn't sound like you have any regrets, but I'm going to ask you anyway. Any regrets? Anything that you wish you'd done that perhaps somebody beat you to it?

Vint Cerf
Well, occasionally, I wish I'd made a few billion dollars so I could give more money away. But the honest answer is that my career has gone along the path where that wasn't the wasn't the best objective, the best objective was getting this technology out into the hands of people who could expand on it. So, I was very happy to see my colleagues start companies, make internet happen, you know, spread across the world. And to the extent that I helped to enable that, I found that extremely and still find it very satisfying. So if there's any regrets, it's that this platform can be abused and it is abused by people who don't mean you and me or others well, and that's why we still read Shakespeare 400 years after the plays were written because he still illustrates in the most amazing way all the foibles of human behaviour, and we see it reflected in the internet. And we have to try to do something about that.

Sue Nelson
Vint Cerf, thank you very much for joining me on the Queen Elizabeth Prize for Engineering's Create the Future podcast.

Vint Cerf
I'm happy to do this. It's an enjoyable conversation. What else is more fun than talking about yourself?

Sue Nelson
[Laughs] That's right. And you're gotta give me that again, when I asked you give me some levels. What was that line again?

Vint Cerf
Oh, this is the dominion network of the Canadian broad-corp-in-castration.

Sue Nelson
[Laughs] Not much I can say about that, thank you.