HRH Crown Prince Tupouto'a of Tonga

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Welcome to the Dandin Chronicles!

Editorial note:

It's safe to say that all of us are here because at some level we welcome the opportunity to explore new territory, transcend the rules, do something that works better, and pass it on.

In the case of Dandin, it's the chance to build, demonstrate and deliver a superior approach to Internet connectivity using wireless technology. Taking outside-the-box approaches to both technology and business models, Dandin is unconventional even by Silicon Valley startup standards.

Not coincidentally, our first customers are those who haven't been served particularly well by existing models and also welcome the opportunity to do something better. The next issue will include a report from the South Pacific Kingdom of Tonga, where **Crown Prince Tupouto'a** envisions a future in which his idyllic but isolated country leapfrogs the Industrial Age entirely and becomes a prosperous nation of knowledge workers. A key component of his plan is the high-speed wireless network Dandin will be deploying in the months to come.

The Dandin Chronicles will be reporting frequently about ongoing projects, as well as people inside and outside the company as the extended Dandin community grows. Please feel free to offer suggestions as to what you'd like to see Chronicled.

-Mary Eisenhart (marye@dandin.com)

The Origins Of Dandin

In which founder/CEO Dewayne Hendricks explains the technical background, history and vision of the company

ME: So how did Dandin come into being?

DH: Dandin, to me personally, is the continuation of a start-up that I did a number of years ago, started in 1990 called Tetherless Access Limited (TAL). I founded that company in 1990 with Charles Brown. What we were trying to do was something like what Metricom was doing, but we were trying to do it in a different way than they were doing it, a different business model.

Metricom originally started out as a company to provide data delivery to the utility data market. They morphed the company into doing Internet data later on once that became a much more perceived lucrative endeavor.

What we were trying to do was to do wireless Internet over a metropolitan area using unlicensed spectrum.

My background comes from using the ARPANET at Southern Illinois University back in '72. I also had a background in IBM mainframe. I sort of knew what was going on in terms of what the possibilities, the potentials, were of a network of connected computers.

I was first licensed to ham when I was twelve. I have had a background in radio for a long time even though my academic training is in engineering and electronics. But I had sort of gotten OD'd on amateur radio and I had been out of it for some time. It was actually Glenn Tenney who got me interested in it again.

A guy named Phil Karn had written a packet radio program that ran on the PC. Phil made the code available for non-commercial use , for free , for anybody in the amateur radio community. He was looking for people to port it to other platforms. I took on the task of porting it to the Macintosh, and wrote MacNET. I made it available as shareware.

By porting Phil's code to the Mac you certainly could do packet radio, but you could also do regular Internet stuff with it. I supported Ethernet interface for TCP/IP long before Apple did.

That really got me interested in radio and that led to the formation of Tetherless. We saw an opportunity to do wireless Internet.

The business model we had in mind was unlike Metricom's. They wanted to own the infrastructure. We decided to let the people participate in the infrastructure. If you owned your own land or whatever, if you wanted to put up an antenna up on your structure, on your property, that's your right. As you got more people to do that, that would build the infrastructure. Instead of what Metricom did, which was go and get a franchise from the city, rent lamp poles. It took them a long time to get that lined up going city by city by city.

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ME: You were going to do it on a more grassroots basis.

DH: Yeah, because we were coming from the ham radio background.

What most people don't realize is that amateur packet radio started about '82 and its basis was DARPA. In addition to funding the wired Internet, DARPA had sort of funded wireless Internet. A project called Project Suran at SRI back in the late '70s and early '80s spent a lot of money on developing a survivable packet radio network and developing spread spectrum radio. In fact, the technology of Rooftop, a company that just got bought by Nokia, is based an a lot of that Suran work.

Back in the early '80s, the hams dusted off that intellectual property that had been languishing and developed a low-cost implementation of it. TAPR, Tucson Amateur Packet Radio, a non-profit 501(C)3, was instrumental in doing this. They developed a device called a TNC, a terminal node controller. It allowed a computer to connect to a radio ; it had a bunch of firmware code in it that essentially allowed hams to set up self-organizing, or self-routing, packet radio networks.

You get your set up and attach a computer and a radio together. The TNC would listen and see what other stations it could hear, and it would construct a routing table. That was it. You could say "I want to send a packet to so-and-so," and it would figure out how to get to so-and-so, just like the Internet works.

By '85, hams had built this transcontinental packet radio network, which sort of became an existence proof of the notion. If you give people technology, they can construct a wireless Internet that could do miraculous things. You could put an email message into the system in the San Francisco area and it would go hippity-hopping across the country using VHF and UHF radio, maybe 40-50 miles to a hop across country.

This was all people voluntarily setting up these stations and this network.

The idea behind ham radio for packet radio network was for emergency communications. For instance, in '89 when we had an earthquake here in the Bay Area and the whole communications fabric went down, the ham packet radio network still worked, and handled traffic until the regular communications network came back on line. Most people don't know that.

Today there are basically two versions of this network that actually operate globally, just like the wired Internet. There is a network that runs on a protocol called AX.25, that's amateur X.25, called the BBS Network, a bulletin board system. That exists today.

There is another wireless packet radio network that uses a TCP/IP protocol that's basically based on Phil Karn's code on different platforms. There's one in the whole Bay Area that goes from San Jose up to Santa Rosa and over to Sacramento. This metropolitan area network is linked to other metropolitan area networks in other parts of the world by the wired Internet. A protocol was developed to tunnel AX.25 packets through the wired Internet, AX/IP.

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Where the AX.25 network used more of a hippity-hop-across-the-country scheme, the TCP/IP implementation uses the wired Internet to go long distances. But hams have their own satellites up, which most people are not aware of either. Those satellites are used to cross the water. HF radio is also used to cross the water, but at lower data rates. Basically today you have radios that hams can buy off-the-shelf and do anywhere from 1200 bps to several megabits, that are used to construct these networks all over the world. The TCP/IP versions are more suitable for high volume.

Here in the Bay Area there was sort of an upper-echelon ham community that has a bunch of mountaintop sites. They have been running a very advanced digital communications network on 5GHz that spans the whole bay. They're doing voice and data and video, a workstation sitting on mountaintops connected to the Internet, all types of stuff. Hardly anybody knows about it except this secret fraternity. They don't write about it. They've been asked to write articles about it and try to spread the word, but they just sort of decline.

As part of that upper-echelon ham radio community in the Bay Area, I have access to those people and that technology. I've done my own version of it, my own mountaintop site. I've written articles about it, but I'm the exception.

This code I'd written for the Macintosh was the intellectual property basis for TAL. What we started out trying to do was find the right kind of radio. We went around and talked to all the major radio companies. We needed a spread spectrum radio to put this code on, to do all this, to implement what is called a mesh packet radio network. Peer-to-peer.

I always thought that client/server was just sort of a wild departure in the wrong direction.

ME: It's essentially the mainframe again.

DH: Yeah, it's going back to the mainframe. The enterprise has gotten into this whole client/server stuff for years.

I was going around telling people at that time that the Internet's the future, you could do it wirelessly for free, and peer-to-peer was the architecture of the future. Those three things really put us ...

ME: Those differentiated you from the mainstream.

DH: We couldn't convince any of the radio manufacturers to partner with us. We would show them the existence proofs, which are the amateur radio network, and say "Look at what people have done. Let's just commercialize this and we can really kick butt."

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They didn't see the market. Why would anybody want to do Internet?

I remember giving a talk in DC at a conference in '94 saying this. There was just budding awareness of things like the Web at that time. Gopher was in full swing then. In '94 I was saying the same stuff to telco people there, people from the FCC. They thought I was nuts.

We were able to convince a local company, Cylink, to build a radio for us. It took about a year of effort to get them interested enough to do that. We were also able to raise $1.5 million to get the company kicked into high gear.

We actually built a product, a packet radio using the Cylink radio. They developed a special version of it that had a special firmware load, so the software developed could talk to that radio and change all its parameters. It could change the spreading code, the power.

To do real spread spectrum, you've got to have what is called automatic power control. If you're doing packets, you 're going in direction X with somebody and it takes a certain amount of power to get there. Then you go another direction with somebody else and it takes a different power level.

The whole notion of this radio is a problem of scaling. What Cylink was doing with their radios, they were treating them like virtual wires -- basically the first time you sent data over the radio the transmitter would turn on and stay on.

Now, think about it -- you've got all these radios with the transmitters on full power, all the time. It doesn't take a rocket scientist to figure out that eventually you reach a point where you can't add any more. That's what Cylink was running into in their overseas sales situation. They were selling lots of units into Buenos Aires, and eventually they filled up the spectrum. You couldn't add any more radios because they were all on --- it was the tragedy of the commons.

That's because they had this virtual wire design. It wasn't packet-based. We would talk to them and say "Look, this is inefficient. You're killing yourself." They wouldn't listen.

This brings us up to about 1995. I was CEO of the company. We deployed some networks and we were certainly demonstrating that the stuff works. But we were still running into the same problem with the Internet and the business model -- why would anybody want to do this? Also, we were using unlicensed spectrum and people were saying, well, it's going to get congested.

Metricom had deployed by then, and we were able to show our ability to operate on top of Metricom and not interfere with them. I remember putting one of our setups down at Apple's main campus in Cupertino, on one of the buildings. Metricom had gotten permission to mount their stuff on Apple's roof. We were 20 feet away from the Metricom installation, operating and sending data up the west side of the Bay.

The thing about radio is that it's a black art. It's pure wizardry. The deployment and how you deploy is really the key. It is sort of a lost art-- during World War II we had this thing called the Signal Corps. There were a lot of people trained to do things with radio, with all the skills necessary. Then after the war there was no need for that skill set anymore. A lot of those people gravitated to the commercial sector.

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What has happened in ham radio is that to deploy at microwave frequencies, which is like a GHz and above, you really need to know what you're doing. A radio system is comprised of three main pieces. The radio itself, the transmission line, and the antenna. Each one of those areas is high black art.

ME: Not only does each one have to be effective, but they have to work together effectively.

DH: Exactly. So, you screw up any one of them and you're dead. As you get to these higher frequencies, the real trick is getting the power that the radio puts out to the antenna, and from there coupled to space.

If you're not careful you could lose most of your energy in the transmission line. Over the years hams have perfected a low-power mode of operation. They use low power -- a watt or something, or even less -- and figure out how to go long distances. I learned those skills when I was coming up from being a kid and involved in radio. I had been indoctrinated into this secret fraternity.

ME: And you knew what the issues were, which put you ahead of the pack to some extent already.

DH: Exactly. And actually ahead of a lot of the commercial people. The people that came to the commercial sector were younger and they didn't have the skill sets. And they weren't into ham radio.

We hams have been having our own conferences for about 18 years, with published proceedings. A large body of art has been developed about how to do this stuff. Problems have been solved, protocols have been developed. All kinds of stuff. Sometimes somebody in the commercial sector will do a patent without checking prior art, and *voila.*

The government spent a lot of money during the DARPA days on packet radio and spread spectrum, so there's a lot of prior art. We found that there is a lot of stuff that you could just build upon, which is what we did.

That's where I was coming from for the basis of TAL. To me a lot of this stuff that you see being done with radio today in the commercial sector is like, been there, done that. I'm more interested in really pushing the envelope to take up where the DARPA stuff left off, which we still haven't really.

ME: So what became of TAL?

DH: We had to raise more money. I wanted to get back to getting a real radio. Now we had money and sort of a reputation and people were starting to say, "Boy, these guys aren't crazy when they are talking about the Internet."

I went to Jim Omura, a recognized expert in spread spectrum who wrote one of the seminal textbooks in the field. He's chairman of the board and one of the founders of Cylink. I said, "Jim, we need a spread spectrum radio."

We needed a spread spectrum radio that has what is called a process gain of 50 dB. That means you can deal with an interferer that is about 50 dB in strength. It's able to operate in the presence of a very strong signal.

The military developed spread spectrum to do covert communications. You can't jam what you can't find. That was the idea about building scalable packet radio networks-- you could deploy these things, and you could have a zillion of them in an area, and they wouldn't interfere with each other.

ME: Because they would only be using the piece of spectrum for a fraction of a second, then move on.

DH: Right.

A number of people came to the Federal Communications Commission in the early '80s that had experience in military spread-spectrum systems. They knew what was possible with these systems, and they were trying to get the commercial sector to adopt these systems for communications. But what was going to be required was a paradigm shift at the Commission.

The Commission was enabled by the Communications Act of 1934. Embodied in that act is a 19th-century view of spectrum. It's a scarce resource, so minimize its use.

In the early '50s, Claude Shannon came out with his Law, which basically related noise to information processing. He showed that if you want to have more efficient use of spectrum, you should use more of it.

What's happened is that the Commission forced us, as engineers, to figure out how to push more and more data through small slivers of spectrum. You get these complex modulation techniques and what you essentially end up having to do is use more power as the bit rate gets higher, to keep above the noise level.

But if you use more spectrum, like lots of it, which is what spread spectrum is about, you end up using less power. And you can pack more people into the same area, which is what Qualcomm figured out.

Some of the founders of Qualcomm were early member of TAPR and also were also on its board of directors. Over the years TAPR has been sort of a home for a lot of talent like Phil Karn and other people like that who gave their time and intellectual property to TAPR. What TAPR has done is license the technologies that have been developed. That's how they continue to survive over the years.

have been developed. That's how they continue to survive over the years.

The early Qualcomm founders went on from TAPR into Qualcomm. Taking that same knowledge base with them, you see what they've been able to do. But they've applied all their stuff basically to the voice domain rather than the data domain.

But when it came to building us a radio to do this, Jim couldn't do it. He said "Dewayne, I know what you need. I understand why you need it. But I just can't get my company to do it." Cylink was into encryption and security by then. That was becoming their prime business, even though the radio business was making money.

I had to make a decision that I couldn't, as CEO of TAL, tell potential investors "Give us money, we're going to conquer the universe." So I resigned

I left in February of '95. That's when I hooked up with Dave Hughes, who I'd met at a TAPR meeting in Colorado Springs. Both Dave and I talked at a community networking conference Steve Cisler put on at Apple, and Larry Irving from NTIA heard our talk. He went back to the Beltway and talked about it, and people from NSF heard about it. They asked the Colonel to put a grant proposal together.

I did that for three years. It was basically the one grant. He just got more and more money added to it, like for the Mongolian project. Most of the work was in the San Luis Valley in Colorado. We had basically fifteen school districts in urban and rural Colorado.

The Mongolia Project was bringing the Internet to a country for the first time. There was a lot of skepticism, but once we got the radio network up and the University was connected, things changed. The word got out to the government and we had these people from various Ministries come to us and say, "Look, could you come over to our Ministry?" It got so bad that the Ambassador had to call a meeting at the embassy. But it was clear at least in that country that radio had a lot of potential.

That brings us up to about the beginning of '98. I was friends with Paul Baran, who is one of the founders of Metricom, and also founder and chairman of Com21.

At the time, living in Fremont, I was one of the first @Home users. From June '97 I had this cable modem, but to me it was just a block box. It delivered bits.

Paul said, "It's a radio transceiver." I said, "Oh really? Wow."

He says, "Look, the way you've been building radios, you're never going to be able to do it as cheaply as a cable modem. So if you use the cable modem as the basic foundation of a radio system, you're going to be a lot further ahead." He convinced me to come on board at Com21 and set up this skunk works -- we call it an independent business unit -- I was supposed to get Com21 into wireless. I came aboard in February of '98. I figured out how to take the Com21 cable modem system and turn it into a wireless system.

Before I got the cable modem, I had a system I had put up on Mt. Allison in Milpitas in the fall of '96. In '95 I got my *warpspeed.com* domain name. I had a 56kb connection into my home that I was paying for--at the time 56kbwas big bucks -- and I had a microwave link that would shoot that connection up to Mt. Allison. I was redistributing the Internet using unlicensed spread spectrum radios to selected friends.

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When I got the @Home connection in June of '97 I now had two feeds. Of course, I used the higher-speed one, so I was shooting that 10mb up to the top of the mountain.

I put a Com21 system up there and had some other stuff developed on a contract basis to augment it and to make it work in the wireless domain. I pursued the same kind of strategy of putting the right kind of people up on the network.

This network did 30mb downstream and 2mb up, using cable modem connected to computers. I started to make some decisions on where this could go from a business standpoint. It was more of a broadcasting model.

The cable industry is more of a telco model. I have always been in the symmetry camp. That comes from my early experience in the Net. Also, we built ham radio networks to be symmetric--you want to be a producer. The people who were paying for Dave's project were the Internet people at NSF. They were into symmetry. They were funding projects like CU-See-Me. They were saying, "if CU-See-Me catches on, people are going to be sending video upstream."

ME: And the cable companies really didn't want to hear that.

DH: Yeah, they didn't want to hear it. All this money was being spent by the telcos and the cable companies for a wrong model. Here we are going into a world where it's doomed. It's just doomed. It's not going to work.

We're seeing that in Fremont now. We were symmetric 10, using fiber to the curb. They spent a lot of money in Fremont as sort of an experiment. Well, people started using it -- surprise!-- and the upstream system wasn't there.

So they started changing the usage agreement. No video. They metered the upstream to 128kb. We've got hardware in here that can do 10mb upstream and we can't use it.

So symmetry is very important. I could see problems with what I was doing at Com21. It was like, been there done that, and going in the wrong direction. What was happening with cable modems was that the cable industry was dominating the standards process. They didn't want to put anything in the cable modem standard that would make wireless easy. Wireless was like the Antichrist.

I could see where they were going. While Paul had a great idea, the sands were shifting. It became clear to me that I really wanted to participate in doing a paradigm shift. I wanted to get back to real spread spectrum, which is what I was trying to do at Tetherless. The rules were such, again, that I couldn't do it. Even in ham radio you can't cobble enough spectrum in one segment to really do spread spectrum.

The industry, all these wireless LAN products, Home RF and stuff you're hearing about-- they're all going to fail because they won't scale. They're not really spread -spectrum devices.

ME: They're going to get saturated?

DH: And interfere with each other. You the consumer buy a cordless phone, then you buy a wireless LAN product--the two won't tango together. But the wireless industry doesn't say this.

I started looking around for a place where I could use the technology I really wanted to, and it became clear that it had to be a sovereign nation, where I could make a deal with the government to get all the spectrum that I want and use it however I wanted. Unfortunately, there are not that many places on the planet that fit those requirements.

But as luck would have it, this network that I have had up since '96 has been very useful. It's got a lot of inroads to various things-- my being appointed to the FCC Technology Advisory Council really comes from doing this, getting the network up and writing papers about it. I'm on the TAC to represent the small entrepreneur, the out-of-the-box kind of deal and ham radio.

So the word got out to Eric Gullichsen, who's a business partner with the Crown Prince of Tonga, His Royal Highness Crown Prince Tupouto'a of Tonga, who we'll just call HRH.

Eric wanted to develop a clone of this network in Marin County, where he and some of his friends live, because they wanted to bypass the telco. He came down and I showed him my network. They went up and cloned it. Then he told HRH about it and on one of his trips, last December, he came to Com21 and visited me.

I pitched him my vision. It was: see this network I've got up here? I can do the same thing in your country. And by the way, in exchange I want all the spectrum I can eat.

He liked that. He had made up his mind that he wanted to transform the telecom infrastructure of his country. He had already taken over power generation. The next stop on the road was telecom.

He had been approached by a lot of companies in New Zealand and Australia, which pretty much dominate that region. He decided, well, wait a minute, why am I going to go with these guys when I can go to Silicon Valley? I sort of fit the bill for what he wanted to do, and at that meeting he made a decision to trust me.

From that point on, he went out and decided he needed to raise the money to fund this thing. He did his own math, and said "I need to raise about $10 million (Tongan)." That's about US$7 million. By April he had raised that money. He came to me and said, "Look, I did my part, it's your part now."

I was going to use Com21 equipment, plus I had gotten involved in ultra wideband technology. You can consider ultra wideband technology as sort of superset of spread spectrum. It works in not only the frequency domain, but the time domain.

From my experience in Mongolia I knew that you don't go anywhere like this and just have one system because if it doesn't work, what are you going to do? So, I

just have one system because if it doesn't work, what are you going to do? So, I wanted to have two systems. I went to Tonga and installed the system, let's call it a pilot. I shipped a Com21 system there. I also shipped a system from a company that was in Belmont, and now in Santa Clara, called Wireless, Inc. They had an unlicensed spread-spectrum radio that was pretty slick. I talked them into sort of donating their stuff to the pilot.

As it turned out, that was really the right thing to do, because I couldn't get the Com21 system to work. But I was able in short order to get the Wireless, Inc. system up, and so we were able to get a number of the schools up on the net, wirelessly, and also HRH's home.

ME: And there is a reasonably fast satellite connection?

DH: Well, no. The satellite connection that Cable & Wireless runs is only 128kb.

ME: To the whole kingdom?

DH: Yes.

ME: So I have a better connection to my house than the Kingdom of Tonga has to the world?

DH: Yeah. They have a 64kb connection to the Royal School of Science. When I put these schools on, it basically just ate up that bandwidth. But it demonstrated that I knew what I was talking about.

It was clear that I now had the basis to go out and start a company. So that's what I did. That is what Dandin is all about.

ME: Who are the people at this point?

DH: What I wanted to do in terms of putting together a core team was get technologists. I wanted people who had been through start-ups before and were facile in more that just one field.

Steve Purcell was at Xerox PARC in the heyday. He was the manager of AI research at PARC. He has done a number of startups-- he was a founder of C-cube Microsystems. He was also a founder and CTO of Chromatic Research, which was sold recently to ATI. Steve is a good technologist.

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Greg Jones, who's the President of TAPR, has been involved in packet radio systems since he was knee-high to a pup.

Stephen Ludvik, a Ph.D. EE from Stanford, has been involved in the Valley running his own engineering consulting firm. He is just an all-around good electrical engineer. He has done satellite systems, all kinds of stuff.

That's the core technical team. ■

Calendar

Events of Interest to Dandin

Conferences:

EDUCAUSE 99

Celebrating New Beginnings

Long Beach (CA) Convention Center

October 26-29

http://www.educause.edu/

ISPCON

Fall '99-San Jose Convention Center

October 26-28

http://ispcon.internet.com/

Meetings:

The Thursday Pubs at the World Internet Center
http://www.worldinternetcenter.org

Lectures:

Tech Museum Members "Meet the Author" lecture series Oct.18, 7:00 pm. "The Web: Past, Present and Future" by Tim Berners-Lee, author of newly released book, *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web By Its Inventor*

http://www.thetech.org

Upcoming birthdays:

Dewayne 10/11, Mary 10/22, Steve Ludvik 11/7.

Who's Doing What...

In the ambitious undertaking of establishing a paradigm-shifting startup and launching its first project, the Dandin team has been hard at work in recent weeks with everything from meeting with investors to persuading varied technologies to get along.

Much-traveled **Dewayne Hendricks** recently spent a week in Tonga forming local partnerships and otherwise preparing to deploy Dandin's network there. He's also been traveling coast to coast in the US, attending meetings and conferences of such entities as the FCC's Technical Advisory Council and TAPR. In addition, he and financial maven **Todd McMahon** have been meeting with prospective investors in the company.

Meanwhile, Chief Non-Technical Officer **Alice Butterick** has been engaged in paperwork, meetings, paperwork, meetings, and more paperwork and meetings, punctuated on research on everything a fledgling company might need, from attorneys to business cards.

On the technical side, **Steve Purcell and Steve Ludvik** contend with the intricacies of delivering voice-over-Internet functionality, while **Greg Jones** has been working on technology transfer from TAPR to Dandin, as well as managing Dandin's 900Mhz FHSS radio.