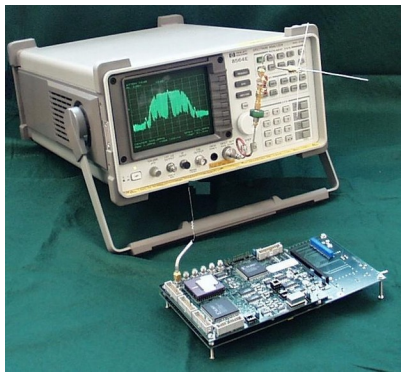
CSIRO WiFi Technology – no mistake!

John O'Sullivan

22 June 2023



US005487069A

United States Patent [19]

O'Sullivan et al.

[11] **Patent Number: 5,487,069**

[45] **Date of Patent: Jan. 23, 1996**

[54] **WIRELESS LAN**

[75] Inventors: **John D. O'Sullivan**, Ermington; **Graham R. Daniels**, Willoughby; **Terence M. P. Percival**, Lane Cove; **Diethelm I. Ostry**, Petersham; **John F. Deane**, Eastwood, all of Australia

[73] Assignee: **Commonwealth Scientific and Industrial Research Organisation**, Australia

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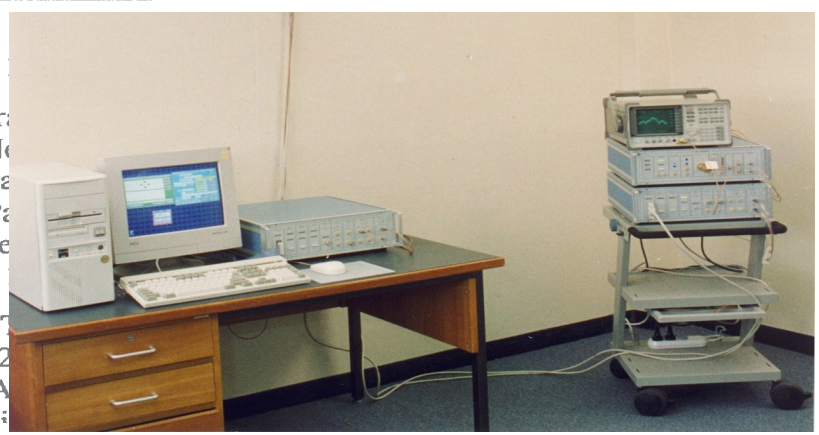


An unfortunate message …

Michael de Nil, Founder & CEO Morse Micro, sent me this a few weeks ago from a bar not far away!

The reality: A diverse team with varied backgrounds worked hard to come up with an answer to “cutting the wires” – high speed wireless networking.

What follows is a very short version of that story.

Set the scene in CSIRO Radiophysics

Late 1980's

Australia telescope now separate

All groups targeting 30% external earnings

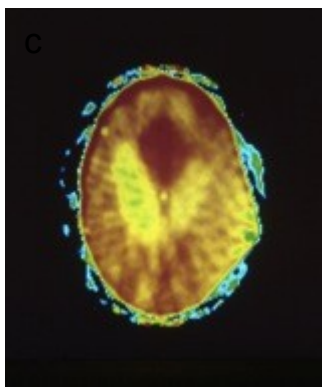
=> Lots small projects – difficult to make an impact

Needed to get small number of large targets

- Need more "wood behind one arrow"
- Larger, diverse teams able to tackle big problems

Example: Signal and Image Technology Program

- Medical imaging, underground communication and safety, radar, geophysical imaging, FFT technology, adaptive filtering, algorithms and hardware for radioastronomy,...



Set up a new group - PLANS

Prof Bob Frater

Focus on telecoms so called "Last Mile" problems

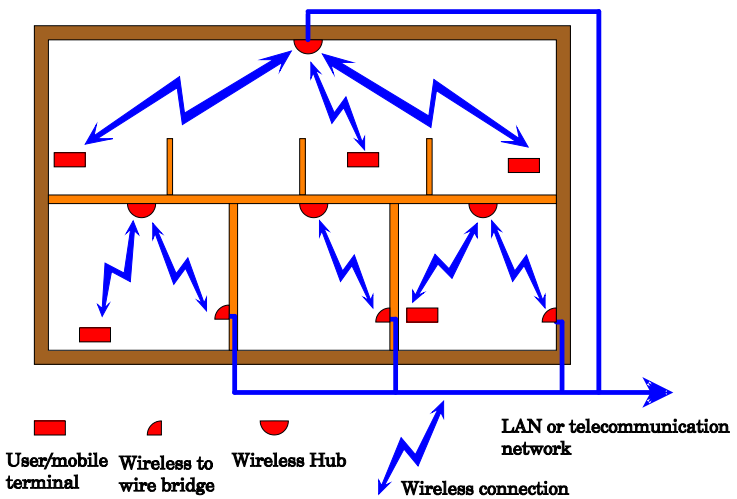
- Radio, antennas, propagation, signal processing, networking, etc – experts from multiple other groups joined in

Wireless Local Area Network (WLAN) was a great fit

- Computer networks and portable computing were just taking off in 1990
- Existing WLANs were slow
- Ethernet, FDDI (fibre) were difficult to install and move

100 Mbps data rate goal – turned out to be very important!

- Would allow real video, potential new apps with computer-computer comms (intelligent agents)
- Match best wired networks - wire replacement
- A stretch goal which meant we had to come up with something different.



Wireless Networks

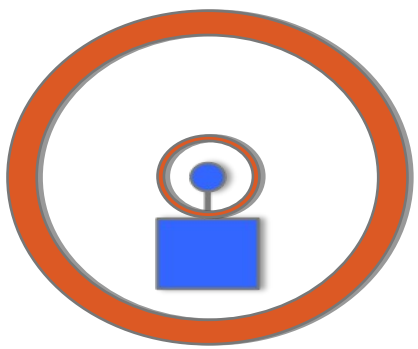
University Hawaii – 1971 Alohanet – inter-island comms.

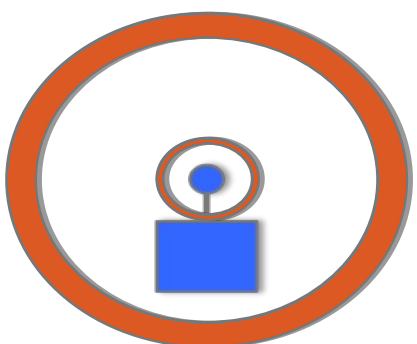
Send short "Packets" of bits from station to station

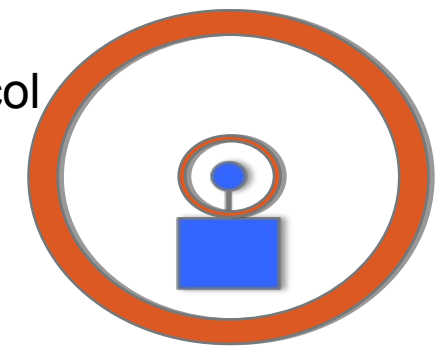
Simple protocol – Aloha

- Only transmit if no one else is
- Add random backoff -> Ethernet cable network protocol

Then current wireless network versions too slow!!







High Speed WLAN

At 100 Mbps bits are 10 nsec approx 3 mtrs apart

Signals bounce of surfaces, objects, refract around edges.

- Each bit interferes with multiple bits after it if sent serially

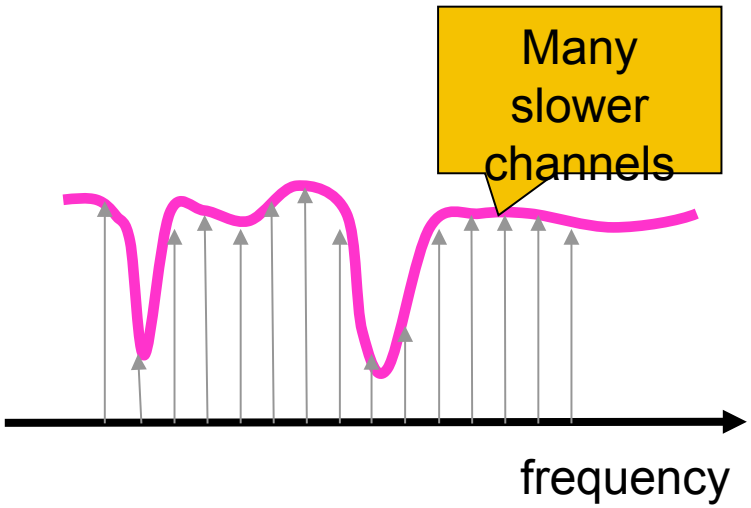
We started by trying to better understand indoor propagation

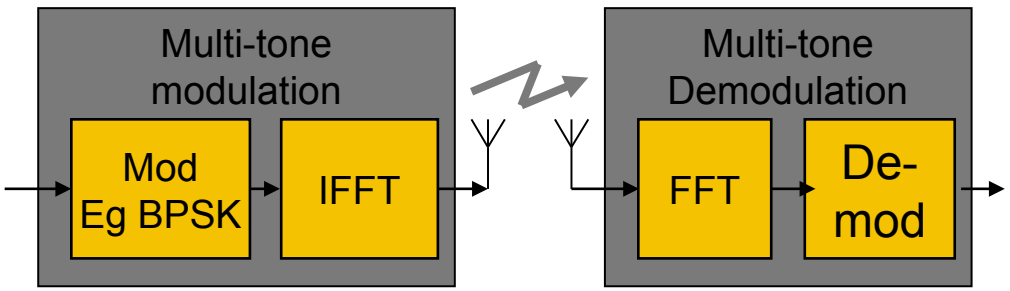
- Time domain – multipath, echos
- Frequency domain – notches in the bandpass

Options considered to combat multipath and need for spectrum

- Equalisers, spread spectrum, agile directive antennas, mm wave (60 GHz), different modulation schemes ...

Answer for the high speed WLAN problem





The FFT is ideal to do the multi-tone modulation - OFDM

With our FFT chip experience, we saw the FFT as a practical part of the answer!

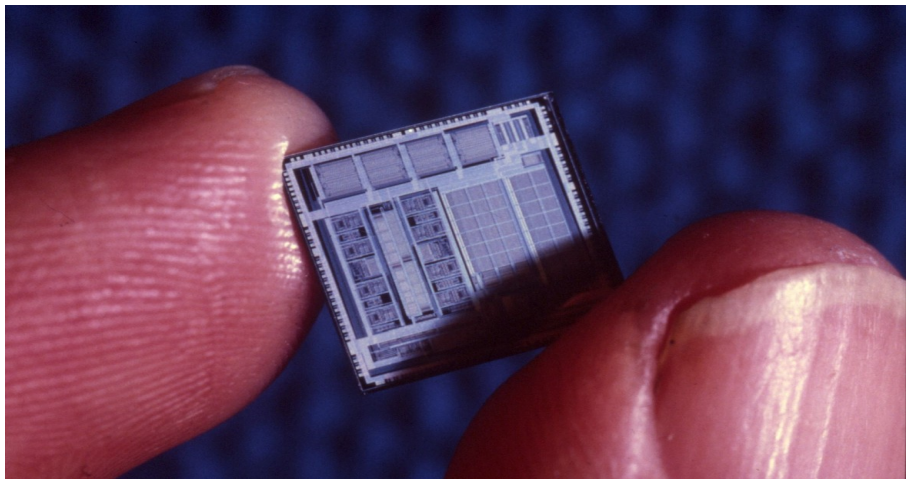
- **Problem is some tones are kaput**

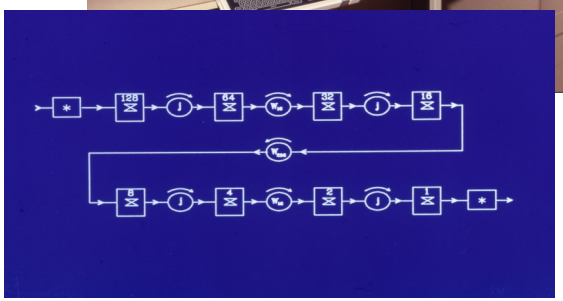
Plus much more:

Coding, frequency interleaving to address failed tones, …

➔ Australian patent 1992, US '96

The Austek-CSIRO A41102 Fourier chip





Bill Stroud

Medical Ultrasound application

- Commercial CMOS version – joint CSIRO/Austek design - 1988
- Various apps such as medical ultrasound imaging, synthetic aperture radar envisaged
- Used in defence, astronomy
  - World speed record holder for many years

David Brown

Chip design

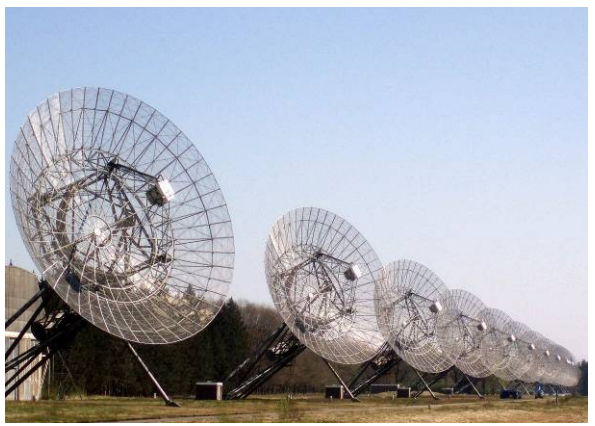
But why FFTs?

Let me count the ways:

FT was fundamental wherever linear time or space invariant response and FFT $N/\log_2(N)$ speedup makes a huge difference (Cooley, Tukey & Gauss (?)

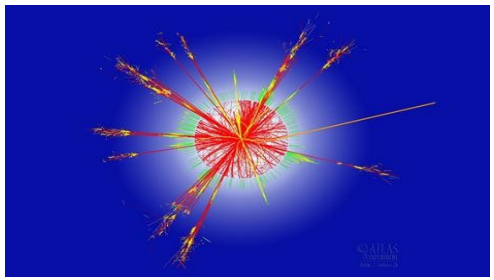
FFT in radioastronomy in the '70-80s:

- Image formation for interferometers/synthesis telescopes
  - Fleurs, Westerbork, Australia Telescope
- High speed correlators and spectrometers
- Digital filter banks
- Compensation atmospheric distortions (twinkling)



Westerbork, 14*25m, NL, 1970

Short time pulse searches

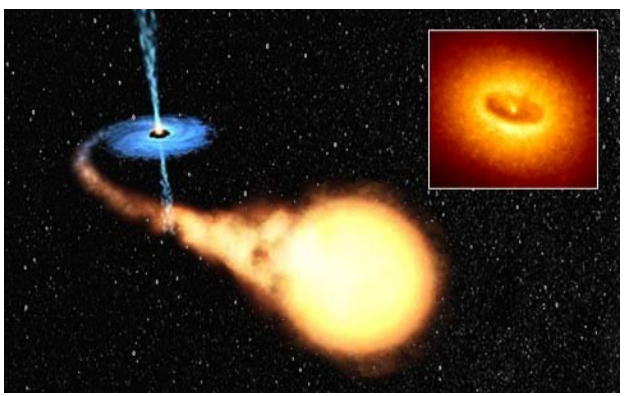


Hawking – 1974

- Mini black holes from big bang
- Radiate and “thermal run away” because smaller = hotter ➔ expire in explosion
- EM pulse detectable at astronomical distances (Rees)

Ekers, Shaver and myself - 1978

- Simple dual pulse detector at Dwingeloo, NL



Prof Stephen Hawking

Lord (Prof Martin) Rees of Ludlow

More searching...

Westerbork with Tim Hankins et al, 1981

M87 pulse search using Westerbork tied array

Acousto-optic spectrograph (Bonn) and film recorder (Dwingeloo solar)

- 100's metres film with noise

Caused me to immediately contemplate hardware FFT options!

- Not much action on FFT hardware until return to Australia in 1983

It's the People – and their backgrounds

John Deane, Denis Redfern, John O'Sullivan, Diet Ostry, Terry Percival, Graham Daniels (some years on in front of an ex-Fleurs radiotelescope dish!)

Also major contributors were:

- CSIRO
  Bob Frater, Dennis Cooper, Alan Young, Tony Sweetnam, …
- Macquarie Uni
  Dave Skellern, Andrew Myles, ...

CSIRO Chairman's medal 2009

- Legal team also done good!
- Settled with ~19 companies
- >US$400,000,000 in royalties
- Half total financed CSIRO funded endowment fund