A SensorWeb – Bringing the world into the classroom.

Professor Paddy Nixon
The University of Tasmania
The Internet of Things is here
Only six electronic computers would be needed to satisfy all the United States computing needs.

Howard Aitken, 1947

Manchester baby – 2000 transistors

10-core Xeon – 2.6 billion transistors

Aitken, 1947
IPv6: Connectivity Without Meaningful Limits

- 52,000 trillion trillion addresses per person
- 100 addresses for every atom on the earth’s surface
- 4.8 trillion addresses for every star in the known universe

IPv4 addresses: 4,294,967,296
IPv6 addresses: 340,282,366,920,938,463,463,374,607,431,768,211,456

Sources: Cisco IBSG, 2006–2011; Steve Leibson, Computer History Museum; CNN

Source: Dave Evans Cisco IBSG
The Internet of Things Is Already Here

<table>
<thead>
<tr>
<th>World Population:</th>
<th>6.3 Billion</th>
<th>6.8 Billion</th>
<th>7.2 Billion</th>
<th>7.6 Billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected Devices:</td>
<td>500 Million</td>
<td>12.5 Billion</td>
<td>25 Billion</td>
<td>50 Billion</td>
</tr>
</tbody>
</table>

Connected Devices Per Person

- 2003: 0.08
- 2010: 1.84
- 2015: 3.47
- 2020: 6.58

Source: Dave Evans Cisco IBSG
Sequence Your DNA In An Hour On This Tiny Chip

LILY NEWMAN  8 APRIL 2013 3:00 PM

Diagnosing genetic disorders and devising personalised therapies just got a lot easier, or at least quicker. Panasonic and Belgian research lab IMEC have created a small chip that tests DNA in under an hour.

The researchers believe that having such quick access to base pair sequences will not only help doctors detect disease-causing abnormalities, but will also allow them to make better, more targeted decisions about which medications and treatments to prescribe. The chip automates the entire process, taking a drop of blood mixed with a chemical substrate, preparing the DNA for PCR, and then running the amplification...
By 2015, 1 Zettabyte of Data Will Flow over the Internet

- One zettabyte = stack of books from Earth to Pluto 20 times (72 billion miles)
- Increase of 540,000 times from 2003; more than 90% from video
- If an 11 oz. cup of coffee equals 1 gigabyte, then 1 zettabyte would have the same volume of the Great Wall of China

Source: Dave Evans Cisco IBSG
Countries in the top tier of broadband penetration have exhibited 2% higher growth in GDP.

Worldbank
The Internet of Things changes everything
• Range Extension Database & Mapping

• Record ‘out-of-range’ species

• Pilot project in Tasmania, started Dec 2009

• Launched Australia-wide Dec 2012

• Hosted by IMAS at the University of Tasmania in collaboration with many institutes

• Winner of multiple awards
Emergence of citizen science

- Exponential increase in papers
- More momentum in land based systems
- Marine systems lagging
Success so far....

• 450 sightings, 70 species from 140 people
• Data used in 3 journal publications so far
• Identify new research projects
• Over 50,000 discrete visits (hits) on the site
• 150,000 page downloads
• Visits from 166 countries
• 750 newsletter subscribers
• Radio, tv, print media
• Many emails requesting more stuff!
• Invitations to present at industry forums
• Climate change & marine species – 3rd most visited section of site
Long-term benefits of Redmap

• Ecological monitoring - species ranges

• Cost effective way to identify where research could be targeted

• Promoting awareness within the general community (e.g. linkages with Facebook)

• Involving & engaging industry - acknowledge & values contribution

• Gives industry and community ownership of some of the knowledge

• Potential to improve adaptive capacity of marine industries indirectly – something constructive they can do to help!

Redmap Australia launches October 2012– 60,000km of coastline and 3.5 million fishers & divers!
Marine sensors and platforms

• The Integrated Marine Observing System (IMOS) is a huge marine sensor network.

• Available for research and tertiary education.

• Providing observations from:
  – profiling ‘Argo’ floats
  – moored buoys
  – ocean gliders
  – autonomous underwater vehicles
  – ocean radars
  – tagged animals
  – wireless sensor networks, and
  – satellite remote sensing

• With open access to all data.
Marine data and information

- All IMOS data, and more and more marine data from other sources
- Are now discoverable, accessible, usable and reusable
- Via a federated, national marine information infrastructure
  - called the Australian Ocean Data Network (AODN)
- That is standards based, open source, scalable
- And internationally benchmarked
  - via collaboration with the EU and USA
With this national marine observing system and data network in place, we are now building the tools to provide a Marine ‘Virtual Laboratory’ capability. That will enable marine and climate scientists to define a domain in space and time and run experiments based on unprecedented levels of access to observations, data, models, and visualisations.
Bringing the (Marine) World into the Classroom

• Advances in marine sensor development, information management, and numerical modelling

• Combined with research sector-wide advances in data storage, networking, and computing

• Are increasingly bringing ‘the (Marine) World’ into ‘the Classroom’

• Our next challenge is to turn these current strengths into sustainable competitive advantage for Australia
Sensing Tasmania
Can we prove carbon neutrality?

Can we protect our citizens from natural disasters?

Can we use our infrastructure most effectively?

Can we manage and use our resources most effectively?

Can we reduce our energy footprint?

Can we become an innovation centre and drive job creation?

Can government deliver more cost-effective targeted services?
Questions every community, town, city, business, state and government worldwide are asking.

Questions that will drive us to realise the productivity dividend of broadband
Tasmania has all the characteristics of more complex global systems. Yet is small enough to enable truly innovative whole-of-system solutions feasible.
Sensing Tasmania is an innovative partnership between UTAS, CSIRO, and the state government to deliver a world first whole-of-system integration.

Minister Crean has announced $3.6 Million to establish SenseT in phase I of a $50 million 5 year programme. IBM, Aurora, NICTA, TasICT, TFGA, Hydro are integral to us building this vision.
Sensing Tasmania will deploy a ubiquitous sensor network to allow us to better understand and manage our resources.

Data integrated through a single data cloud with appstore-esque access.
Goal

To establish a world-leading sensor and knowledge management network to drive economic, social and environmental benefits for Tasmania

Outcome 1
To establish and maintain an efficient and effective core infrastructure

Outcome 2
To design, implement and maintain practical projects

Outcome 3
To maximise community benefit
### Initial Projects

<table>
<thead>
<tr>
<th>Practical projects</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture optimisation</td>
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<tr>
<td>Aquaculture optimisation</td>
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<tr>
<td>Catchment management</td>
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<tr>
<td>Fruit and viticulture optimisation</td>
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</table>
Provide a single data cloud for integrated data

Bringing together: historic data, spatial data, real-time sensed data, and internet harvested.

All with provenance and secure access models
• CSIRO South Esk sub-catchments flow forecasting.

• The semi-distributed flow forecast model implemented by Hydro Tasmania Consulting simulates rainfall run-off in 42 sub-catchments.

• This allows water restrictions to be managed at a much more local rather than catchment-wide scale.
Monitoring in Aquaculture – the concept of sentinel fish

Logged - iLogR®

Physiology and behaviour

- Energetics: maintenance, burst
- Feeding: how much efficiencies
- Environ. effects: temperature, oxygen
- Activity: when energetic costs
- Disease
- Disturbances
New generation iLogR®
- ECG
- Temperature
- Pressure (depth)
- 3D accelerometry (activity)
- Pulse oximetry

Energy = \dot{V}_{O_2} = f_H \cdot V_s \cdot (P_{aO_2} - P_FO_2) \beta_O_2
Light ≡ light/dark
Heart rate ≡ metabolic rate
Temperature
Gape ≡ feeding
Pressure ≡ depth

Animal

+  

OysTag
Scale of knowledge capture unimaginable

Ubiquitous technology penetration

Our students universally need the skills to exploit technology and explore data

Our Universities have to fundamentally address the potential of this technology

Community engagement in all aspects of University now feasible

The University of Tasmania is taking a (technology) leap into the unknown in teaching, research and community engagement
Today's child is bewildered when he enters the 19th century environment that still characterizes the educational establishment where information is scarce but ordered and structured by fragmented, classified patterns, subjects, and schedules."

- Marshall McLuhan 1967
iLogR® – what a fish does, when it does it and how it does it

Environmental conditions
ambient temperature, solar radiation, ground temperature, etc establish operating parameters

Daily

Depth, \( D_M \)

Body temperature, \( T_b \)

Heart rate, \( f_H \)

Activity, \( A_c \)

Seasonal
\( T_{\text{set}} \) and \( P_{\text{max}} \) defined across consecutive days during a ‘season’ with varying environmental conditions will determine preferred temperature (\( T_p \)) and optimal temperature for performance (\( T_o \))

A
\( T_b \) changes
\( f_H \) increases, activity
\( Q_{10} \) effect + activity

B
\( T_b \) constant
\( f_H \) increases, with activity
Can determine aerobic activity

C
\( T_b \) constant
following burst activity
Can determine EPOC

D
\( T_b \) constant
\( f_H \) increases, no activity
animal has fed, determine meal size

E
\( T_b \) changes
\( f_H \) changes, no activity
\( Q_{10} \) effect

Depth, \( D_M \)