



Computational Corals: – *a story of Sensor Networks, Cloud Computing and the Internet of Things*

Scott Bainbridge, Geoff Page and Scott Gardner



AIMS: Australia's tropical marine research agency.

Corals in Decline



- World wide corals are under threat, the 2008 global census shows that worldwide **20% of reefs are already lost**, another 15% are under immediate threat.
- Coral Reefs are particularly **sensitive to climate change**, long term temperature changes of just 2°C can push corals into decline.
- World wide some **300 million people**, mostly in the developing world, **depend on coral reefs** for their livelihood.

AIMS: Australia's tropical marine research agency.

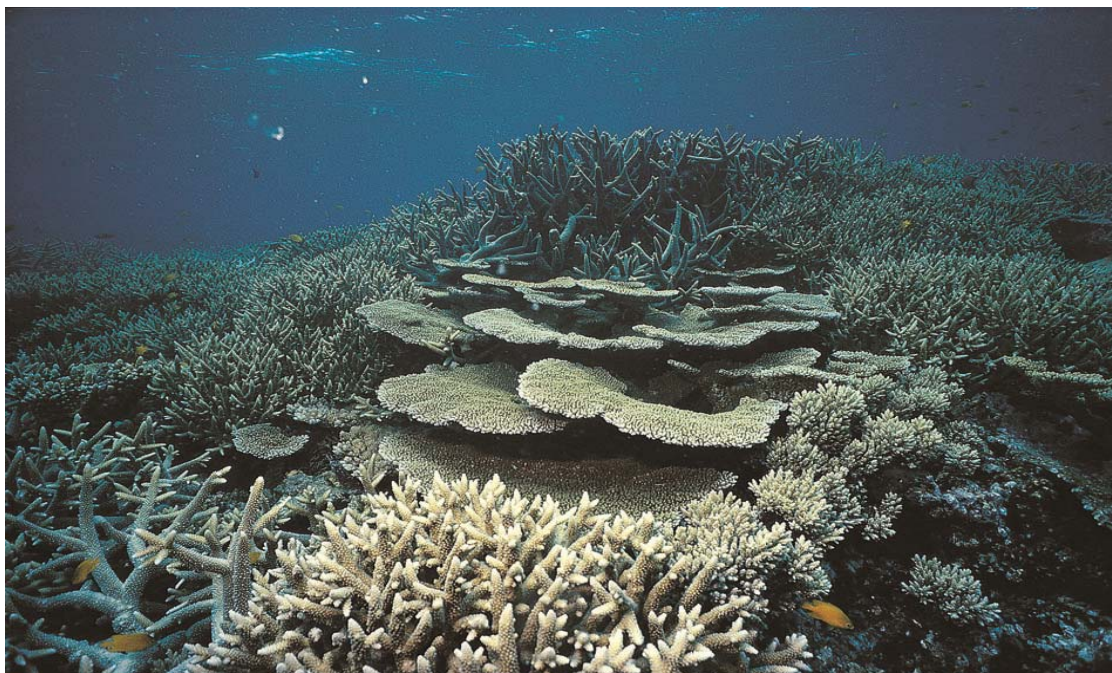
Impact of Climate Change



- Climate change has the potential to increase the decline in coral reefs to the point where current reef systems **may not exist past the end of this century**
- Experimental work shows that long term exposure to temperatures **just 2°C above 1950's temperatures** will make life hard for corals; so far we have **observed a 0.4°C rise**
- Increased CO₂ emissions in the air have changed the carbon chemistry of the oceans reducing pH, if pH goes from the original level of 8.3 **to below 7.9 corals will not exist**

AIMS: Australia's tropical marine research agency.

Potential Scenarios [corals in good condition]



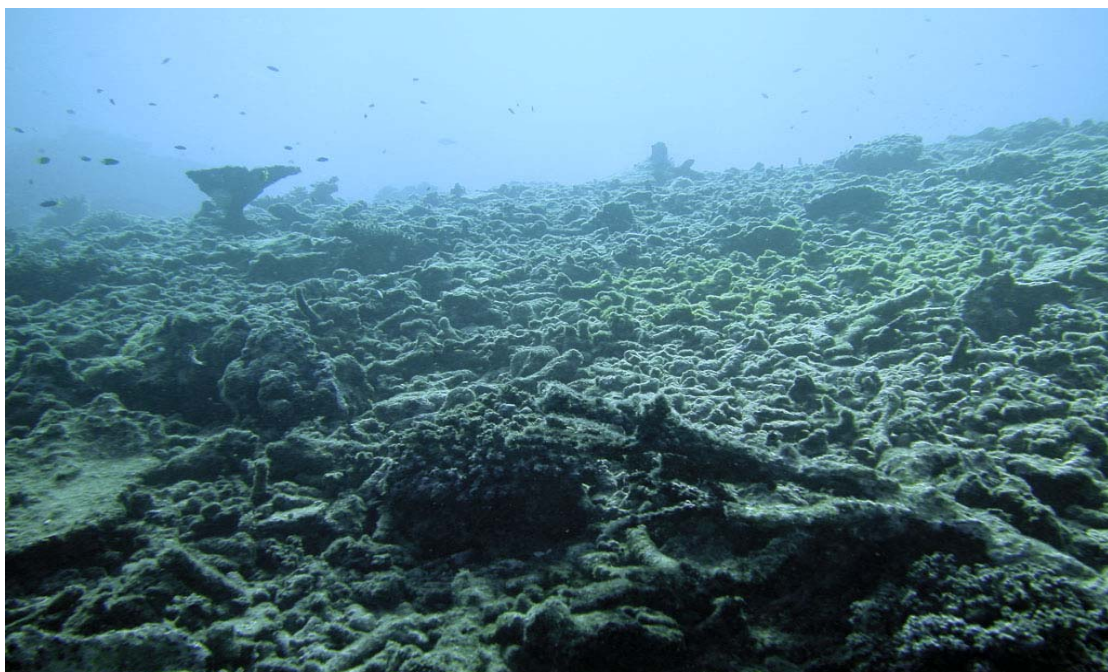
AIMS: Australia's tropical marine research agency.

Potential Scenarios [bleached corals]



AIMS: Australia's tropical marine research agency.

Potential Scenarios [resulting algal dominated reefs]



AIMS: Australia's tropical marine research agency.

The not so great Great Barrier Reef



newscouriermail.com.au

News Video Business
More: news.com.au » News

Shelve new UN report

Save this story to read later
Tweet 0 Recommend

Australia has failed to protect Great Barrier Reef report

Brian Williams | The Courier-Mail | June 21, 2012 12:12

Recommend Send 25 recommendations. Sign recommend.

THE Great Barrier Reef is in danger unless high-risk development proposals are shelved, a UN report says.

The report says no new development proposals should be adjacent to the reef.

It says the scale of coastal development proposals poses a significant risk to the reef.

And the scale and pace of development poses a significant risk to the reef's capacity for independent recovery, the report says.

news.com.au

News Video Business Money Entertainment Travel Technology Fox Sports
More: news.com.au » News » National

'We're in the coal business': Campbell Newman slams UNESCO Great Barrier Reef warning

AAP
June 02, 2012 6:25PM

Save this story to read later

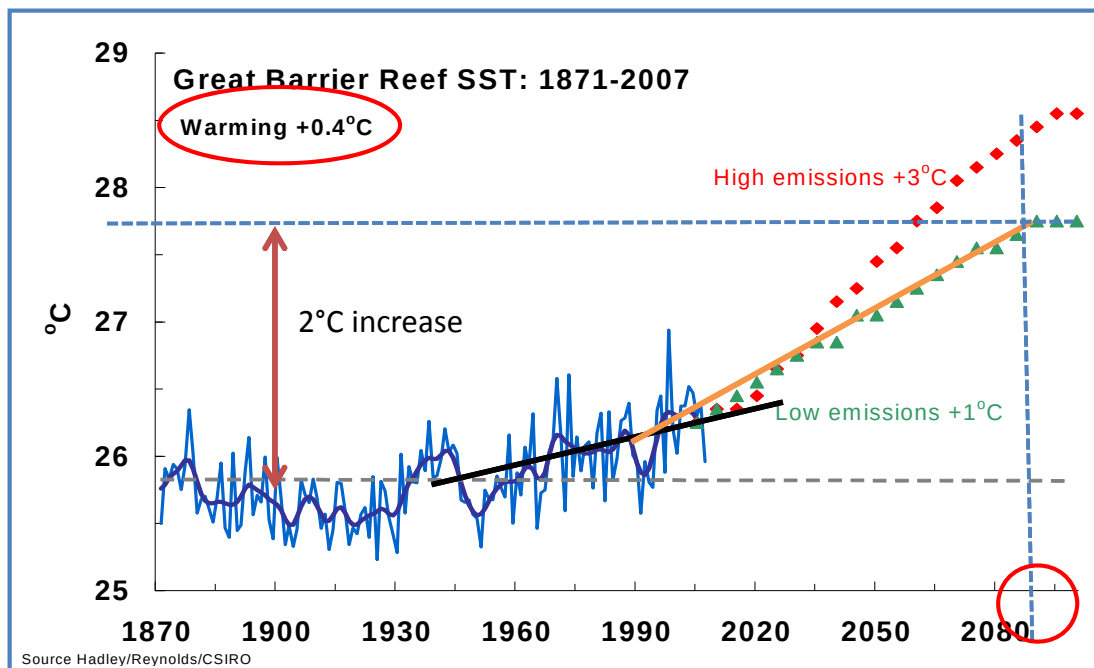
- "Extreme concern" about rapid coastal development
- If development continues, Reef will be "danger listed"
- Australia has eight months to lift game on management

Tweet 47 Recommend 146 recommendations. Sign Up to see what your friends recommend.

Reef UNESCO give Aust

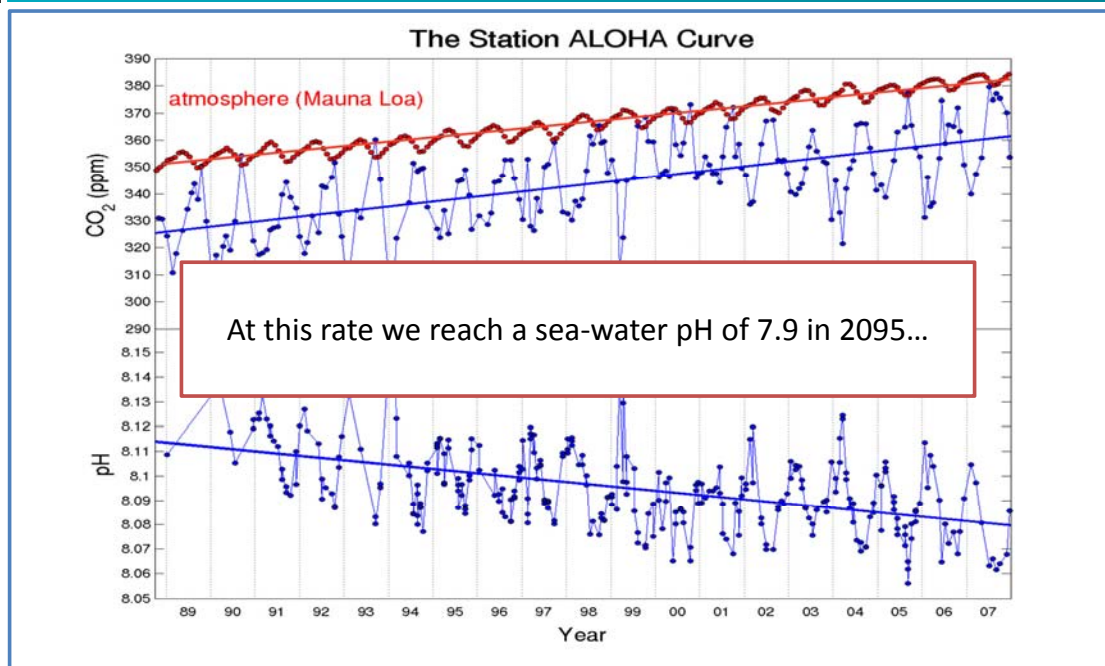
AIMS: Australia's tropical marine research agency.

Changes in Temperature



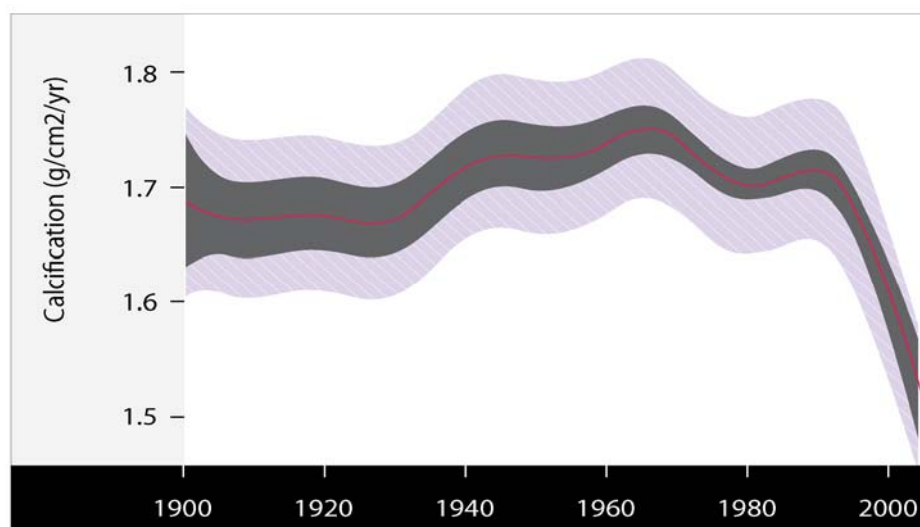
AIMS: Australia's tropical marine research agency.

Ocean Acidification



AIMS: Australia's tropical marine research agency.

Decreases in Calcification



Source: De'ath et al. (2009).

AIMS: Australia's tropical marine research agency.

Observing Systems as one response

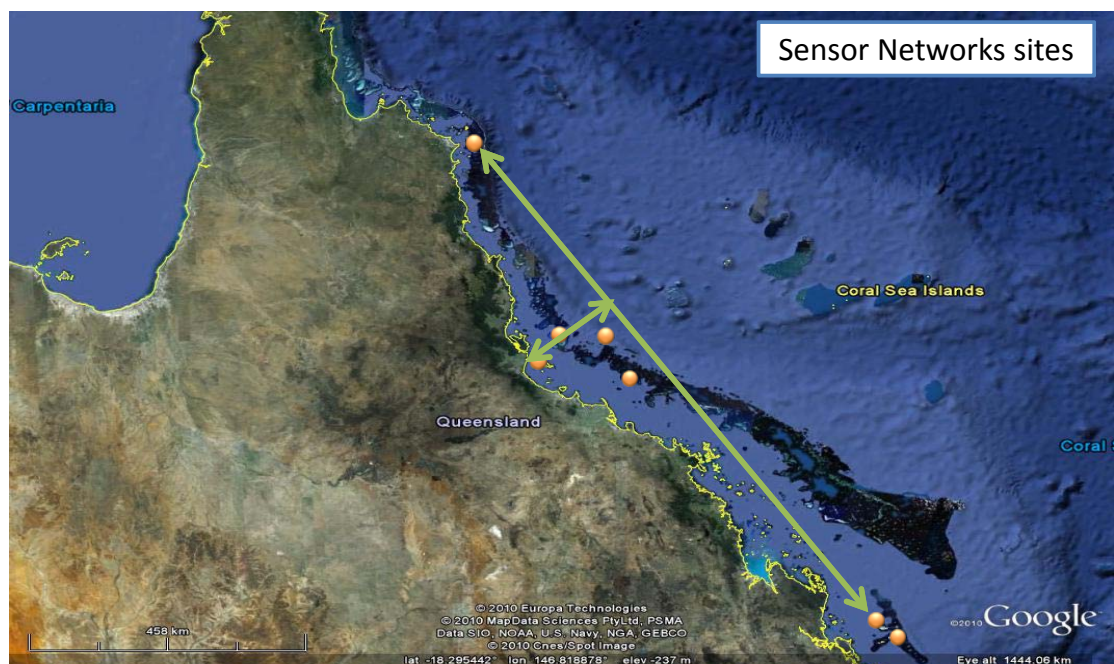


To manage you need to know, to know you need to measure

- Observing technologies have the ability to provide large amounts of environmental data.
- Under the Integrated Marine Observing System (IMOS) a number of **coral reef sensor networks** have been deployed along the Great Barrier Reef.
- These provide **real-time data** on a range of physical parameters including **temperature, salinity, pressure, light, images and video**.

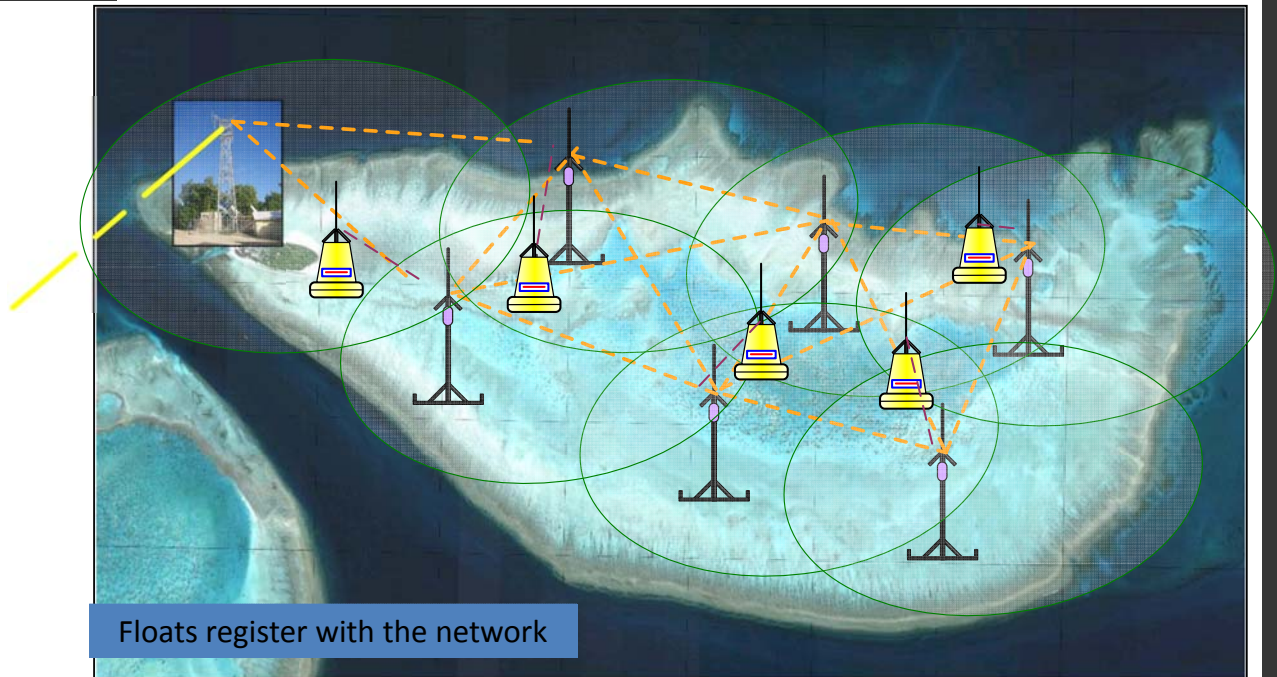
AIMS: Australia's tropical marine research agency.

Integrated Marine Observing System (IMOS)



AIMS: Australia's tropical marine research agency.

Sensor Networks



AIMS: Australia's tropical marine research agency.

Sensor Poles



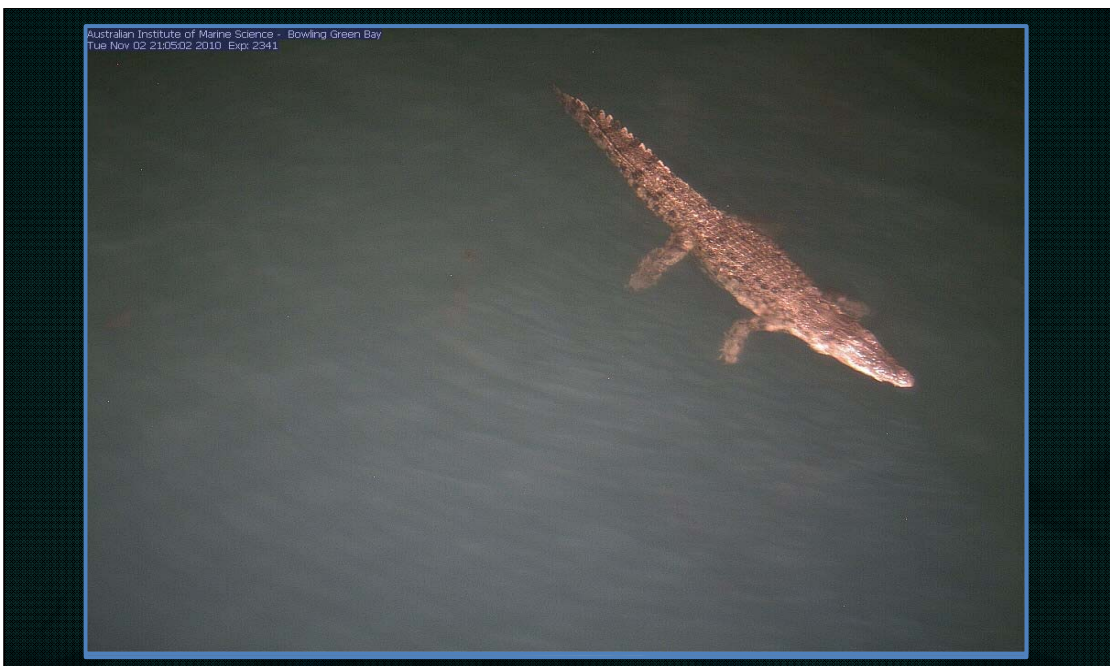
AIMS: Australia's tropical marine research agency.

Sensor Floats



AIMS: Australia's tropical marine research agency.

Instruments



AIMS: Australia's tropical marine research agency.

Communications Solutions



- **802.11n** for high speed on-reef comms including to mobile (raft, quad-copter) platforms (**1-2Km, 30+ Mb/s**)
- **802.11 TDMA** for high definition on-reef video (**1-2km, 30+ Mb/s**)
- **900 MHz** spread-spectrum for longer cross reef comms (**2-5Km, 1200 b/s**)
- **nextG** for back-haul links (**up to 70Km, 0.5-1.5 Mb/s**)
- **5-10GHz** surface humidity-ducted Microwave for long-haul comms (**50-70km, 10-30 Mb/s**)

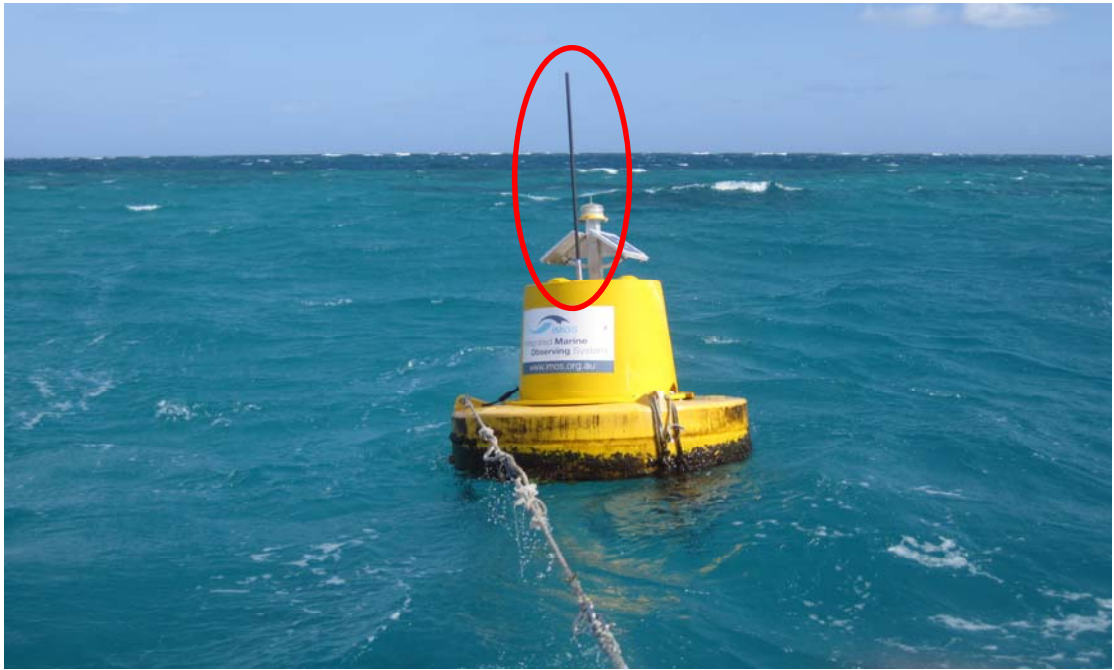
AIMS: Australia's tropical marine research agency.

802.11 Wireless (2.4 + 5GHz)



AIMS: Australia's tropical marine research agency.

900 MHz Spread-Spectrum



AIMS: Australia's tropical marine research agency.

nextG 3G phone comms



AIMS: Australia's tropical marine research agency.

Surface ducted Microwave



AIMS: Australia's tropical marine research agency.

Satellite (when we have to)



AIMS: Australia's tropical marine research agency.

What ubiquitous communications deliver



- Delivers **internet connectivity** to the field (reefs);
- Allows for new types of science such as real-time towed sensors (e.g. **rafts, quad-copters, mobile platforms**), more in-situ instrumentation, etc;
- Cameras and video, ability to have **streaming video** and other high bandwidth data;
- **Remote control** experimental work, remote classrooms;
- Convert platforms such as vessels and jetties into **data collection platforms**;
- Integration of new devices, such as tablets and smart-phones, as **data collection and control devices**.

AIMS: Australia's tropical marine research agency.

What this means...



- Mobile devices will move from **network to network** and from local (institutional) network to public (carrier) network
 - **EduRoam for devices** so devices can move from network to network
 - Tight integration between **educational networks and public ones**
 - **Device level security** suitable for simple low powered devices
- data.

AIMS: Australia's tropical marine research agency.

Context:- Three truths



1. New understandings will more and more come from **multi-parameter, multi-agency, multi-use data**.
2. As we get better at collecting data we need to also get better at **analysing, synthesising and contextualising** – delivering information (and value!).
3. Funding agencies will more and more push towards a model of **open data access and use**.



...and Three Outcomes



1. Data that is not used **has no value** and so activities that generate such data **will (should) not be funded**.
2. **Data hoarding** can no longer be seen as a legitimate way to **keep or gather power** – the power comes from **sharing**.
3. Future success comes from **building architectures** and delivering systems that promote and deliver true **open data access and integration**.

There



AUSTRALIAN INSTITUTE
OF MARINE SCIENCE

- Cloud based data systems **remove** or negate **Institutional systems** and barriers;
- Data as a Service (DaaS) gives data access to an unlimited range of clients from smart phones, tablets, other services (service chaining) and **service agents**;
- **Standards** are the glue that hold it all together.

**REVOLUTION
CHE GUEVARA**

Data wants to be free - Viva la revolution!

marine research agency.

Sensor Networks – revolutionary science!



AUST
OF M



There is a co-operative group called the Coral Reef Ecological Observatory Network (CREON) that is implementing coral reef sensor networks around the world.



Coral Reef Environmental Observatory Network

AIMS: Australia's tropical marine research agency.

Driven by need...



Problem:

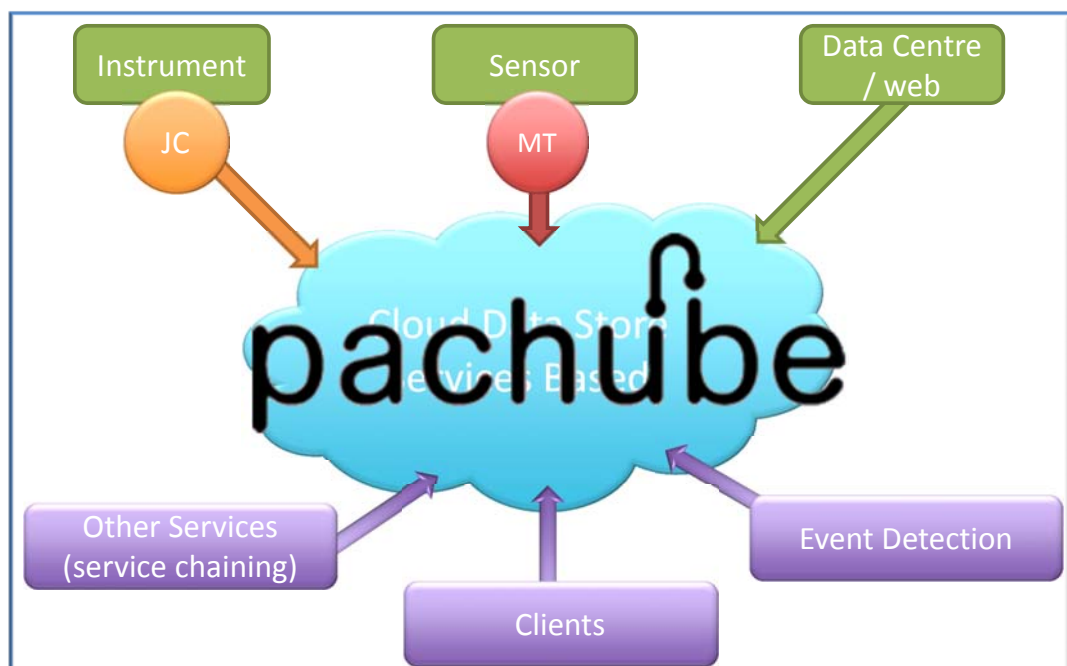
- The need to **integrate data** from multiple sites run by multiple agencies using differing data architectures and **differing custodian arrangements**;
- Need to deliver a **single portal** where all the data can be directly viewed and compared;
- Need to **detect events** at both the site and network (global) level;

Solution:

- Write simple connectors to connect the local data systems into a **single cloud-based storage system**;
- Write other connectors to load in **other base data** (e.g. met. data);
- All data resides in a **single cloud-store** with metadata for searching;
- Using **existing widgets and systems** give access to and display the collected data;
- Using a **simple event detection** engine look for significant user-defined events at both the site and inter-site level.

AIMS: Australia's tropical marine research agency.

Building an Integration Architecture



AIMS: Australia's tropical marine research agency.

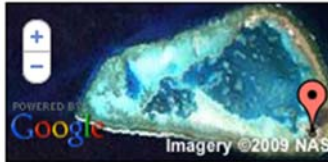
The Architecture in Action



Telstra 3G 1:46 PM

Back OneTree Island

Updated: 2010-01-25T03:35:



2 - Pressure (hPa):



5 - Rainfall to 9am (mm)



Telstra 3G 11:04 AM

Back Orpheus Island SensorNet

Updated: 2010-02-09T00:59:09



1 - SF1 Water Temp (C)



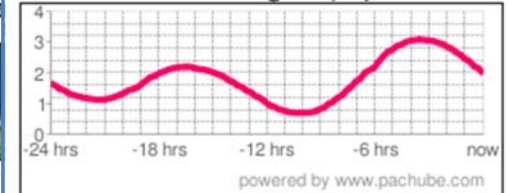
6 - SF1 Salinity (ppt):



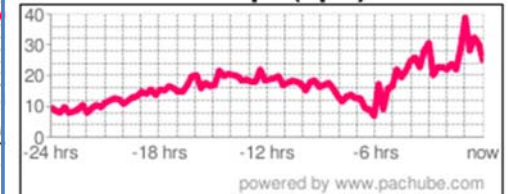
Telstra 3G 11:05 AM

Back Orpheus Island SensorNet

7 - Est. Tide Height (m): 1.96



4 - Max Wind Sp. (kph): 24.48



3 - Humidity (%): 78.0

Social Network Detection

As we get to deliver

One way of interest streams systems

Even better that can

Twitter plea finds stowaway dog on Dublin train

Save this story to read later

ALSO Doctor, doctor there's a 'snake' in my belly

28

Recommend

24 people recommend this.



Thanks to the power of Twitter, Deirdre Anglin has been reunited with her Jack Russell terrier Patch who hopped aboard the train to Dublin. Picture: AP

WHEN Patch hopped aboard the train to Dublin, it took the power of Twitter to reunite the dog with his owner.

Irish Rail sent a "Lost dog!" tweet with a photo attachment after the Jack Russell terrier arrived with Wednesday morning commuters on a train from rural Kilcock, County Kildare, an hour's ride away.

After more than 500 retweets in just 32 minutes, the photo found Patch's owner, Deirdre Anglin, who tweeted the state railway: "That's my dog!"

The episode underscored the ubiquitous use of mobile-friendly social media sites in Ireland, a tech-savvy corner of Europe where mobile phones were the norm long before they were in the United States.

Soon after Patch went missing Tuesday night in Kilcock, 30km west of Dublin, Ms Anglin said she did "the usual social network thing," posting pictures of the dog on her Facebook account and appealing for followers to spot him.

Product Finder

Search millions of prices and brands from hundreds of Australian stores.



better ways data;

define events ual data social media

n alert service of forms.

ical marine research agency.

What it delivers...



- The architecture delivers **true data integration**;
- Removes any **custodian access issues**;
- Brings in **critical mass** of data into a single system;
- Allows for **simple data discovery** and display including smart clients;
- Makes it easy to run **event detection** across the data;
- Delivers the **knowledge in the system** (user defined) in a **user centric form**.

AIMS: Australia's tropical marine research agency.

What it means...



- We can now start to build **critical mass** of observed and other data (e.g. social data);
- We can **chain data services** together to create new products;
- We can build **complex smart clients** against a single data store / format;
- Users can define what the **knowledge in the system means to them** and how they wish to be notified of events of interest to them.

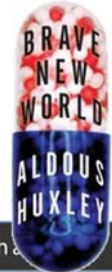
AIMS: Australia's tropical marine research agency.

Where to next... Internet of Things [IoT]



- In the future the internet will not be about humans interacting with data but **machines interacting with machines** delivering information;
- In this M-2-M world services are king (as are the standards behind them), **service wrapping removes any issue about where data is, how it is stored, who collected it and what format it is in**, all data becomes fully accessible in an integrated form.

Brave New World of information delivery



AIMS: Australia's tropical marine research



Wi-Fi tags – Who needs a data centre?

Tag4M

Convert sensor data to web pages using a Cloud Instrument™

Home
Apps/Measurements
Digital Sensor Frame
Products
Contact Us
Blog
Store

Tag4m WiFi tag
Part# 999001-01

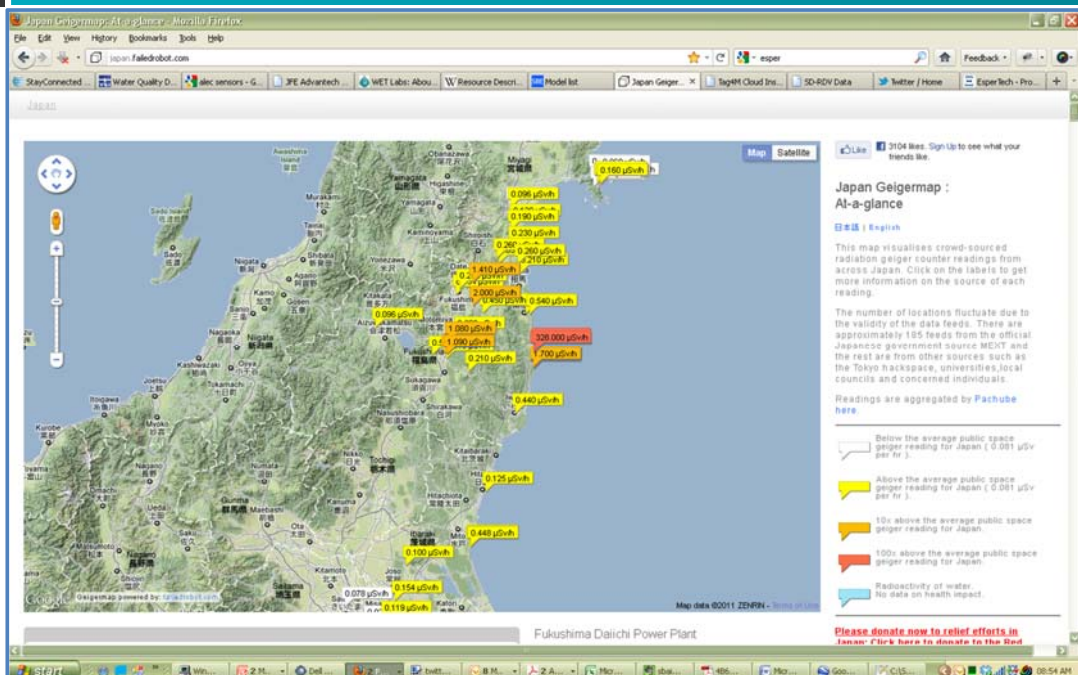
Tag4M is a WiFi Tag. The tag has measurement capabilities for voltage, current, and digital signals. You can build wireless solutions for a wide range of applications by attaching the tag to your sensors or signals. WiFi tags send data to web pages. This is the individual unit price. Extended Temperature Option: Temperature Range (Operating) -40 Deg.C to 85 Deg.C Temperature Range (Storage) -40 Deg.C to 85 Deg.C Relative Humidity (Operating) 90% Relative Humidity (Storage) 90%.

Qty 1
Price \$140
Add To Cart

Tag4m WiFi tag
\$140

AIMS: Australia's tropical marine research agency.

Crowd Sourced Data [turning consumers in producers]



AIMS: Australia's tropical marine research agency.

Conclusion



- The complexity of the issues we are trying to address requires an equally **complex approach** and solution set;
- If data wants to be free we need to build **open collaborative service based systems** that promote integration and sharing;
- All this requires **open, transparent and ubiquitous** communications;
- In the future it will be more and more about **devices** (EduRoam for devices);

AIMS: Australia's tropical marine research agency.

Take Home Message...



There is a **chasm** between where we are now and where we need to be – that is to have the right level of information sophistication to deal with a changing world

The chasm is **not technological** but in our model of how we create, use and access data and the infrastructure it flows across.

Strangely, our ability **to conserve and protect systems**, such as coral reefs, may hinge as much on our ability to be **innovative in our thinking** than in our technology.

AIMS: Australia's tropical marine research agency.

Acknowledgements



Thanks to the various CREON groups including those in the USA, Thailand, Taiwan and in Australia.

Thanks to the AIMS crew for making it all happen.

The Integrated Marine Observing System (IMOS) project is funded under the National Collaborative Research Strategy (NCRIS) and supported by the Queensland Government.



Australian Government

AIMS: Australia's tropical marine research agency.