Digital Technology and the Planet

Swansea University Centenary Year 2020

Zienkiewicz Lecture

Andy Hopper

Swansea 1971-1974

- BSc Computer Technology
  - Computer Engineering
  - Computer Science
  - Mathematics
  - Economics/Accountancy
- Professors David Aspinall and William Gosling

Digital Technology and the Planet

1 Green Computing

2 Computing for Green

3 Trust for Green

4 Innovation for Green

Digital Technology and the Planet

1 Green Computing

2 Computing for Green

3 Trust for Green

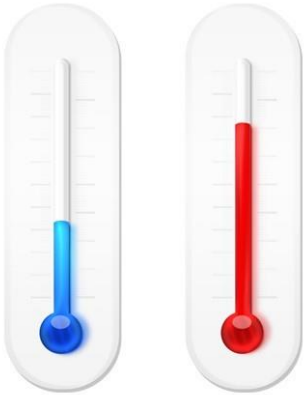
4 Innovation for Green

Green Computing

- Data centre design
- Energy consumption has stayed level despite huge increase in performance
- Energy-proportionate processing, networking, storage

Energy-proportionate Storage (Facebook)

- Hot storage: read a lot
  - Replication/striping across data centres
  - 3.5x stretch factor for resilience and performance
  - Data cools by 500x over 1st year
- Warm storage: read a bit
  - 2.5x stretch factor at lower performance
  - Migrate 1 month old data
- Cold storage: read almost never
  - Cheap drives by the million powered 1/15 of the time
  - 1.4x stretch
- Very cold storage: read never?
  - Optical (eg Blu-ray) thus little energy storage cost



Use of Renewable Energy

- Direct and indirect use of renewable energy (credits)
- Take computing tasks to where renewable energy is currently available
- Unusually sited data centres
- Net-zero is the glittering prize

Threats to this World View

- Running computing tasks without using the results
- Duplication and replication away from the cloud
- Cryptocurrencies using **mined** blockchains – a huge energy black hole

Pollution through Digital Mining

- What is mining?
  - The part that makes it extremely expensive to alter historic records of transactions
- Why is it needed?
  - Enforcing correct behaviour in a distributed context using computational deterrents
- Why is it wasteful?
  - Very expensive to simultaneously enforce **decentralization, consensus, integrity, and replication of the transaction log**
  - Achieved through non-useful computation
- Most applications don't need it

Use of Blockchains

- Limit the amount of data added to the energy proportionate blockchain
  - Do not store data that is easily reproducible
  - Limit historic records to what is needed
- Replace some guarantees
  - eg sharding not replication
- Consider restricted hardware environments
  - Intel Security Guard Extension
  - Root of trust chip

Digital Technology and the Planet

1 Green Computing

2 Computing for Green

3 Trust for Green

4 Innovation for Green

Digital Technology and the Planet

1 Green Computing

2 Computing for Green

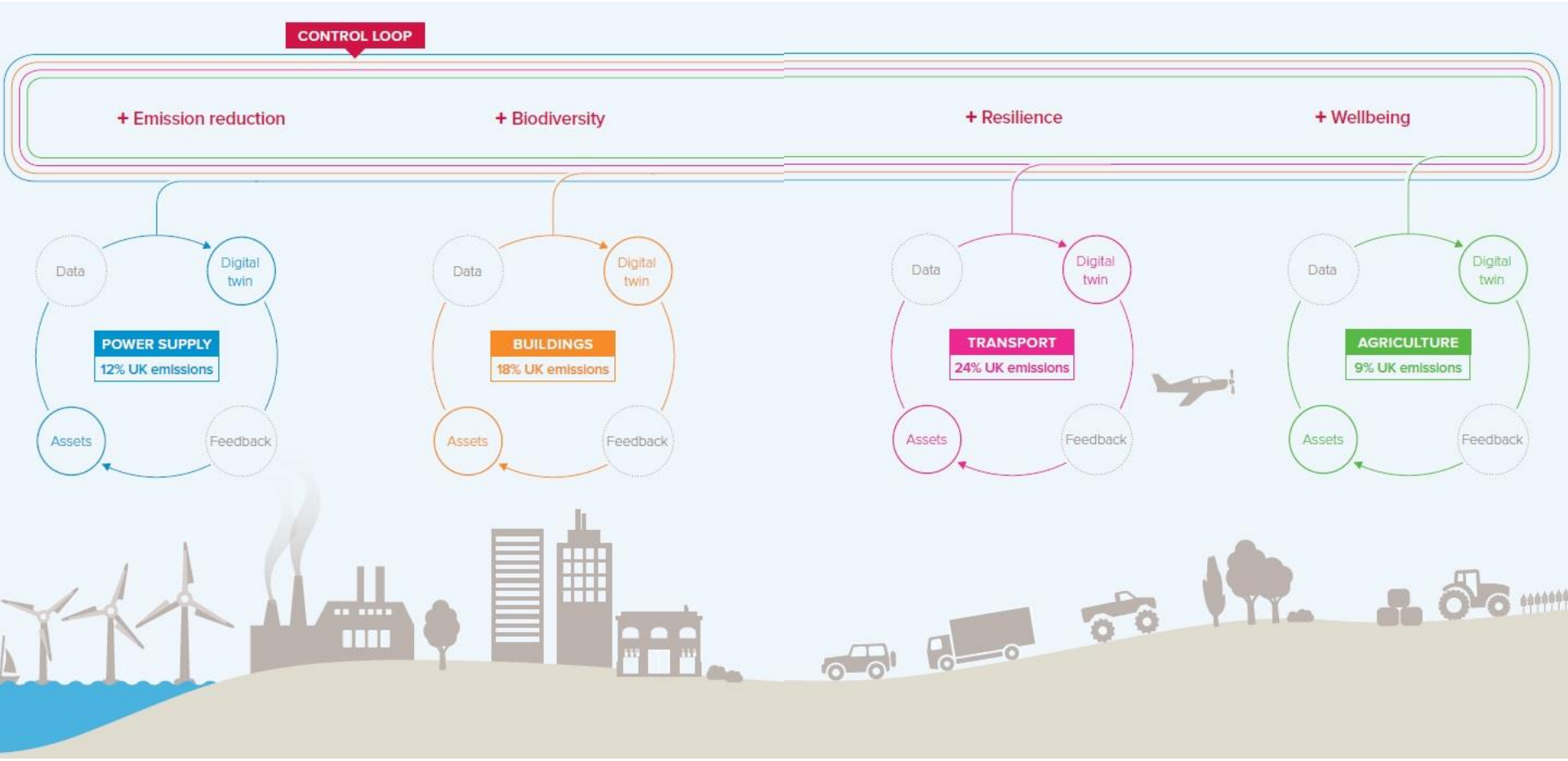
3 Trust for Green

4 Innovation for Green

Computing for Green

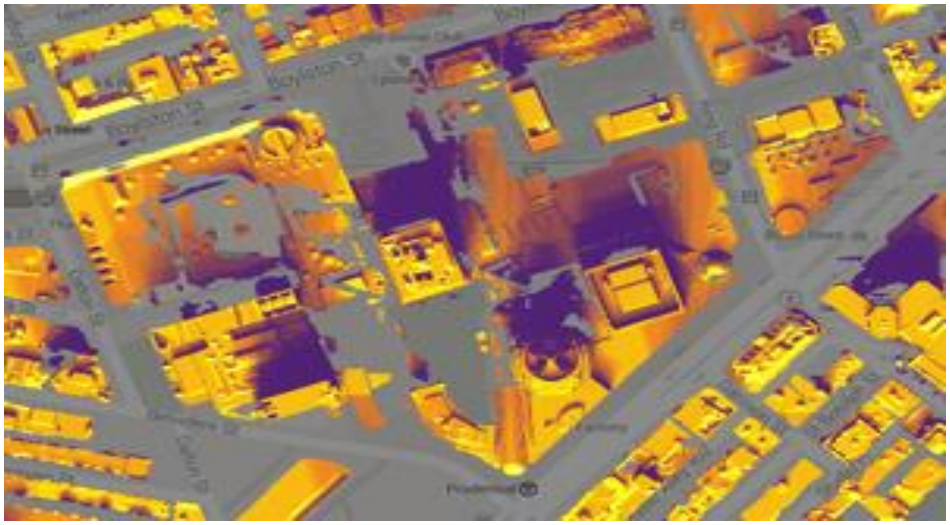
- Sense, model, and optimise everything on the planet
- “Googling” Earth in space and time
- How do we do it?
  - coverage
  - fidelity
  - scalability
  - performance

Control Loop for the Planet



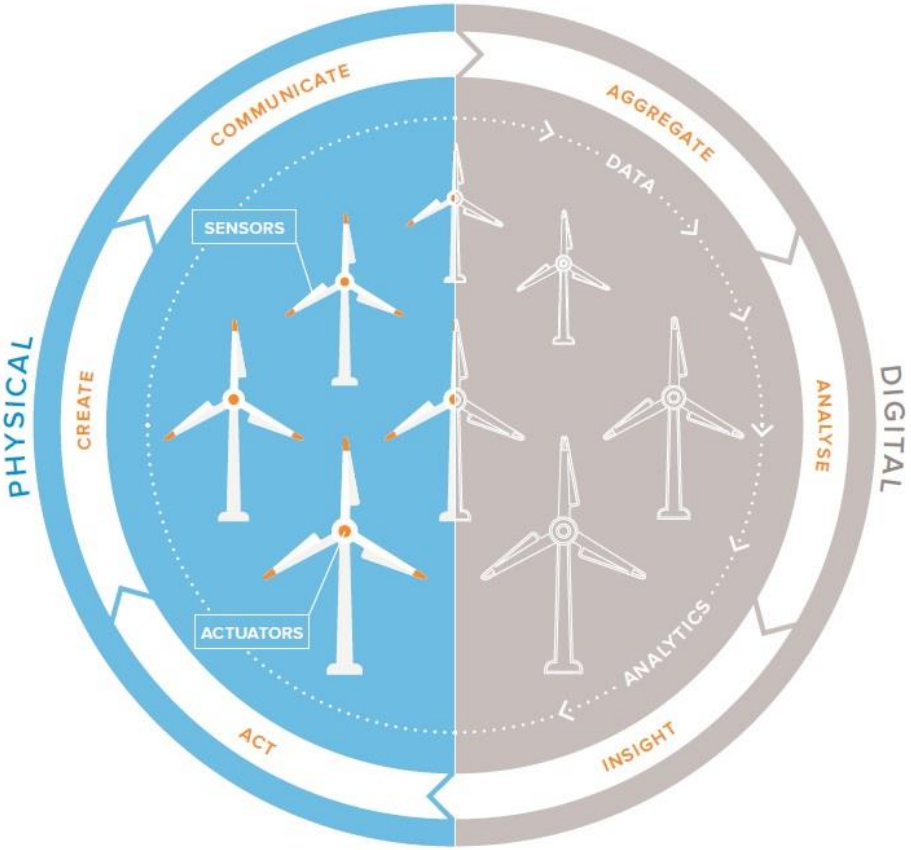
Courtesy Royal Society

Potential Global Sensing Scenarios



- Free solar energy mapping service using Google Project Sunroof
- Other possibilities?
  - Live temperature map of the planet
  - Tracking emissions in supply chains, eg: methane
  - Live map of biosphere
- Should all such services be free like GPS?

Digital Twin for the Planet



- Sense, connect, actuate
- Track and verify
- Simulate
- Integrate, analyse, map data
- Model, optimize, predict (AI)

- Wind farms: design, monitor, proactively maintain, improve design
- Similar to global weather sensing and prediction

Digital Technology and the Planet

1 Green Computing

2 Computing for Green

3 Trust for Green

4 Innovation for Green

Digital Technology and the Planet

1 Green Computing

2 Computing for Green

3 Trust for Green

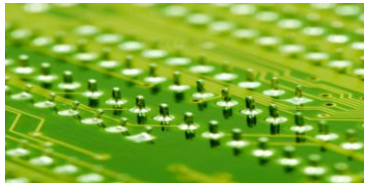
4 Innovation for Green

Trust for Green

- Contestation of Control Loop (eg emissions)
  - Provenance
  - Explainability
  - Audatibility
- International standards and regulation
- Technology will be part of the solution
  - Systems engineering and optimisation
  - Provenance in computer systems
  - Blockchains for immutability of data
  - Privacy enhancing technologies

Root of Trust Example

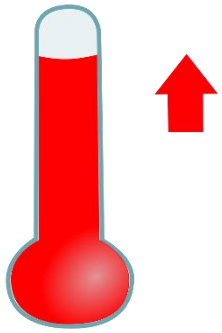
- lowRISC Community Interest Company
  - No shareholders, cannot be bought, “not for profit”
  - Open-source hardware, fully engineered and supported
  - Root-of-Trust by public inspection
  - Funded by donations and industry
- Flagship project is a security-oriented CPU called OpenTitan (RISC-V based)
- Users (eg Google) know system boots from trustworthy state
- A strategic UK asset in relation to technology sovereignty



lowRISC

Digital Technology Against the Planet

- Complexity
- Control loop unstable
- Data-driven unsustainable behaviours
  - More unconstrained consumption
  - More efficient fossil fuel extraction
  - More efficient agriculture trivialising waste
- Sensing beyond sense
  - Surveillance society
  - IoT devices polluting biosphere
- Loss of jobs



Policy

- Laws, public debate, acceptance
- GO FAIR data – Findable, Accessible, Interoperable, Reusable
- Global sharing of net-zero related data
- Role of Governments
  - Regulation for energy proportionate digital systems
  - Financial Conduct Authority guidance for use of blockchains
  - Net-zero a Board level responsibility
  - Data driven carbon credit markets

Digital Technology and the Planet

1 Green Computing

2 Computing for Green

3 Trust for Green

4 Innovation for Green

Digital Technology and the Planet

1 Green Computing

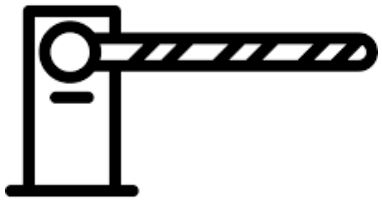
2 Computing for Green

3 Trust for Green

4 Innovation for Green

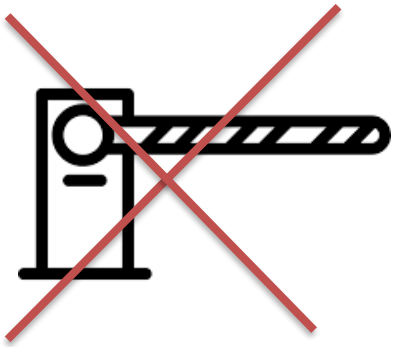
Innovation for Green

- Difficult to build high-tech products
- Complex yet the innovative part may be only 10% of total
- Barriers
  - Build from scratch – wasteful
  - Licence – expensive, encourages rent seeking and hoarding
  - Gatekeepers – IP owners create barriers to entry
- Traditional approaches have not worked well
- Software open-source has not read across to where data represents physical objects



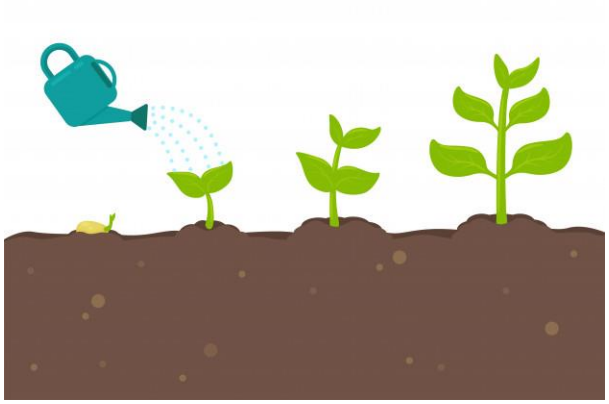
Logical Infrastructure

- Logical Infrastructure is like Physical and Digital infrastructure
- Consists of open, permissively licensed repositories of foundational IP
- A set of building blocks with support and documentation
- A corporate fiscal and legal ecosystem with incentives
- No preference for any region or size of enterprise
- If innovation were a tennis game you would start at 40-love



Liberating Innovation for Green

- Encourage as many net zero ventures as possible
- Incentivize all actors to contribute
- Use lowRISC or equivalent root-of-trust model
- Relevant to all sectors: Health Care, AI, Logistics, Synthetic Biology, …



Digital Technology and the Planet

1 Green Computing

2 Computing for Green

3 Trust for Green

4 Innovation for Green

Conclusion

1 Green Computing

2 Computing for Green

3 Trust for Green

4 Innovation for Green

To be published 3rd December 2020

Digital Technology and the Planet

Swansea University Centenary Year 2020

Zienkiewicz Lecture

Andy Hopper