CO643 – Week 7
Sustainable Computing

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Lecturer

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Outline

- Definitions and dimensions of sustainability

- Computational sustainability
    - Sustainable software
    - Sustainable AI

- Case studies

Some of the materials are inspired by previous years' lectures

Learning Outcomes

- After this lecture, you will be able to
  - Understand what sustainability means
  - Identify how computing can impact sustainability
  - See how sustainability relates to ethics
  - Review case studies for sustainable computing

Definition

- Bruntland Commission - 1987 United Nations
- Sustainable development: *"Development that meets the <u>needs of the present</u> without compromising the ability of <u>future generations</u> to meet their needs"*

Our Common Future

- Raised <u>serious</u> concerns about the current state of the planet
- Introduced the concepts of <u>sustainability</u> and <u>sustainable development</u>
- Recommended <u>policies</u> to be put forward for sustainable development

Role of Computer Scientists

- *Play a key role in developing computational methods for efficiently and effectively managing the earth's natural resources*
  - *Global warming*
  - *Biodiversity*

Dimensions

- United Nations - Agenda for Development (1997)
- "Development is a <u>multi-dimensional</u> undertaking to achieve a higher quality of life for all people"
- "<u>Economic</u> development, <u>social</u> development and <u>environmental</u> protection are interdependent and mutually reinforcing components of sustainable development"

Weak vs Strong sustainability

- Weak: "The next generation should inherit a stock of wealth, comprising <u>man-made assets and environmental assets</u>, no less than the stock inherited by the previous generation"

- Strong: "The next generation should inherit a stock of <u>environmental assets</u> no less than the stock inherited by the previous generation"

Pearce et al (1989)

Strong Sustainability

- Sets thresholds that must not be crossed
- Mostly a matter of <u>social</u> and <u>political</u> preference
- But also a matter of <u>resilience</u>: How well can an ecosystem recover from shocks and stress?
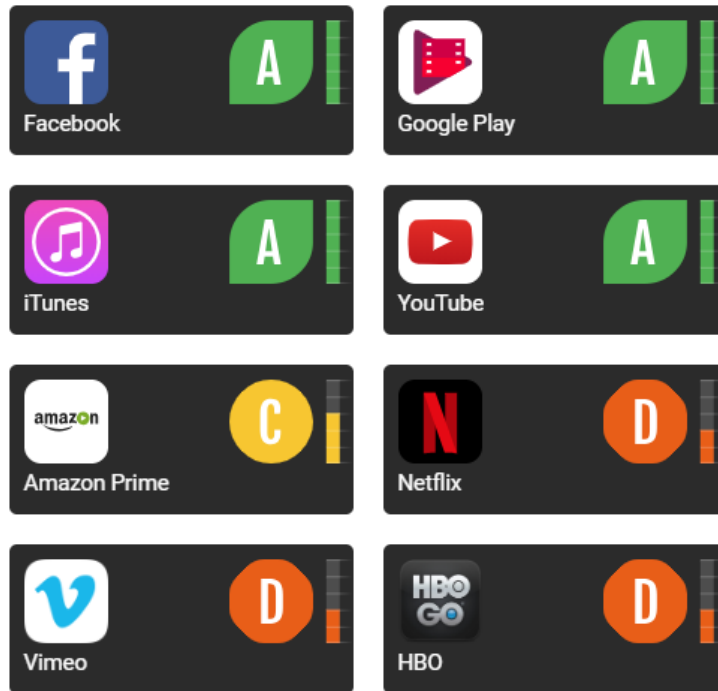- Preferred by ecologists and other natural scientists

Weak Sustainability

- Given the space delimited by such strong thresholds
- Most sustainable outcome leads to the largest amount of both natural and man-made resources
  - Environmental assets
  - Valuable landscapes
  - Cultural heritage
  - Science and technology
  - Infrastructure
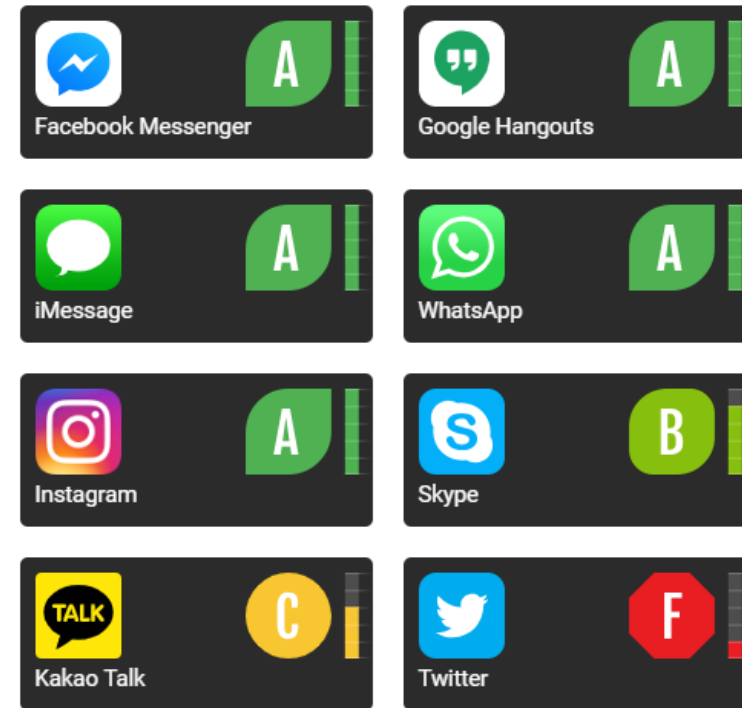- Favoured by economists

Initiatives

- Technology for reducing energy use
- Greenpeace - Green Internet
- Greenpeace - Green electronics
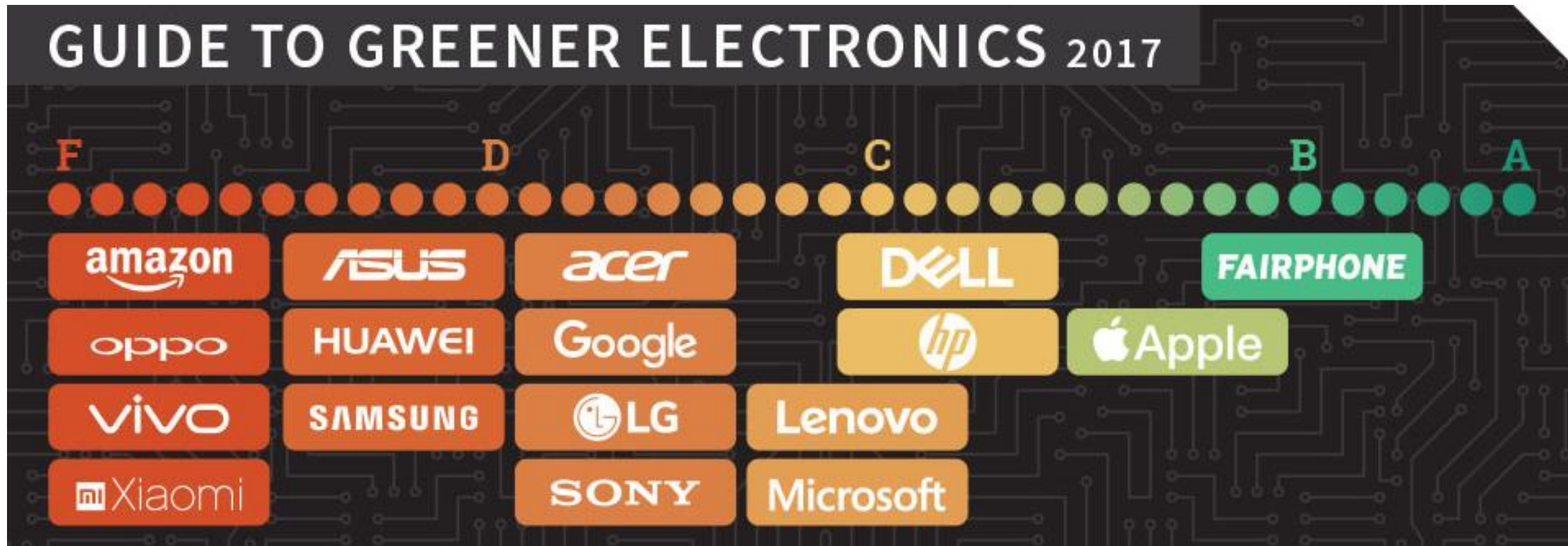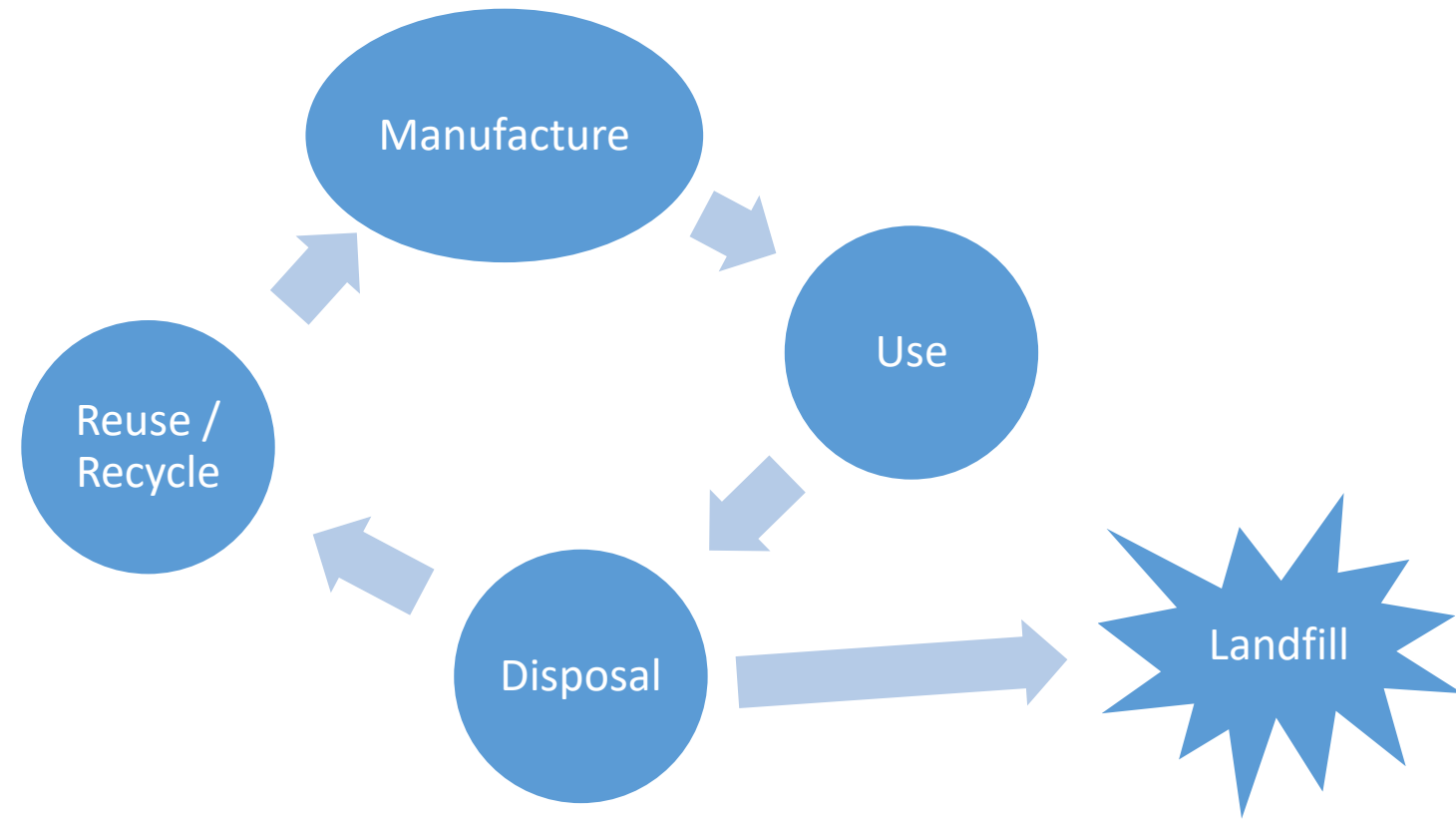
ClickClean - Green Internet

Green Electronics

GUIDE TO GREENER ELECTRONICS 2017

F — amazon, oppo, vivo, Xiaomi

ASUS, HUAWEI, SAMSUNG

D — acer, Google, LG, SONY

Lenovo, Microsoft

C — DELL, hp

Apple

B — FAIRPHONE

A

https://www.greenpeace.org/archive-international/en/campaigns/detox/electronics/Guide-to-Greener-Electronics/

Computer Life-Cycle

Regulation of E-Waste

- Restriction of the use of certain hazardous substances
- Recovery and recycling (WEEE directive)
- Movement of hazardous waste

The WEEE Man

http://www.weeeman.org

Pic by Nick Gregory. 01/06/2005. The WEEE Man robot sculpture
(waste electrical and electronic equipment) towers over the plants outside the
Eden Project in Cornwall as Richard Melvin makes final adjustments from a cherrypicker.

Software Engineering for Sustainability

- **Starts with requirements engineering**
  - Sustainability as a non-functional requirement
  - Process-specific and product-specific goals
- **Focus on quality assurance**
  - Sustainability as a first class quality
  - How to measure?
  - How to verify?

https://isr.uci.edu/content/software-engineering-sustainability-se4s

Sustainable AI

- From "human-friendly" AI to "earth-friendly" AI
- Harnessing Artificial Intelligence for the Earth report
- 8 ways AI can save the planet

AI to Save the Planet

- Autonomous and connected electric vehicles
  - Substantial greenhouse gas reductions
  - Route and traffic optimisation
  - Eco-driving algorithms
  - Autonomous ride-sharing services
- Smart agriculture and food systems
  - Early detection of crop diseases
  - Provide timed nutrition to livestock

AI to Save the Planet

- Weather and climate prediction
  - New field of "Climate Informatics"

- Smart disaster response
  - Analyse simulations and real-time data
  - Determine optimal response strategies

AI to Save the Planet

- Connected cities
  - Smart water consumption and availability
  - Traffic flows
  - People flows

- Transparent digital Earth
  - Monitoring, modelling and management of environmental systems at a scale
  - Tackling illegal deforestation, fishing

Applications & Case Studies

- Academic projects
- Academic conferences and journals
- Smart cities
- Intelligent transportation systems
- Games for educational purposes

Institute for Computational Sustainability

- Aims:
  - To establish a new field, <u>Computational Sustainability</u> focused on computational methods for balancing environmental, economic, and societal needs for a sustainable future
  - Attract a new generation of students who traditionally may not have considered studying computer science
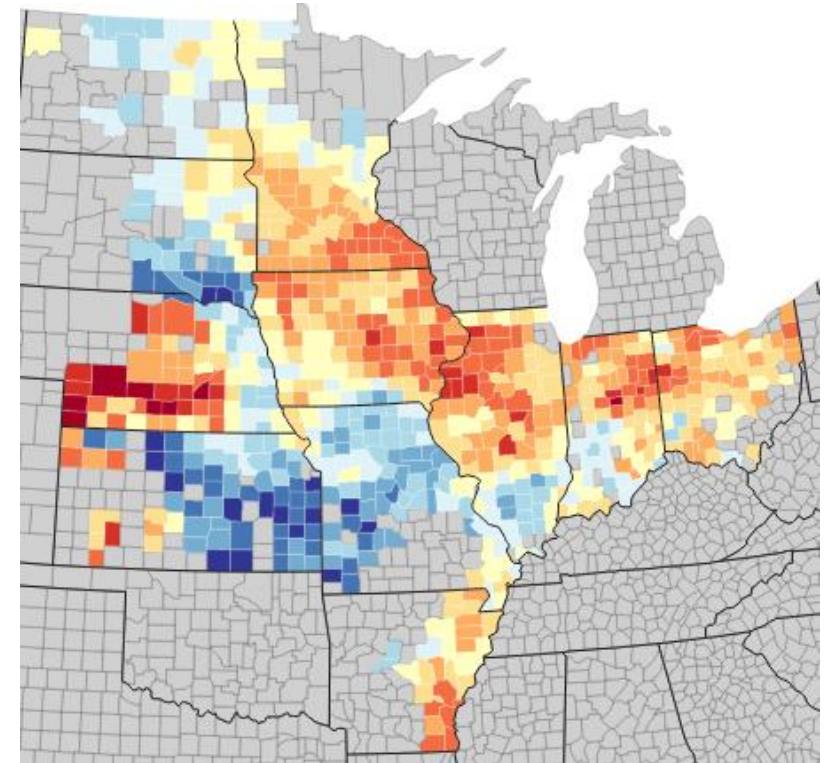
https://computational-sustainability.cis.cornell.edu/

Sample Project: Predicting Crop Yield

- Aims:
  - Understand worldwide crop yield
  - Achieve zero hunger and food security [UN goal]
- Method:
  - Use publicly available remote sensing data and machine learning
  - Predict several months before harvest

http://sustain.stanford.edu/crop-yield-analysis

Sample Project: Wildlife Conservation

- <u>Problem:</u> Poaching of elephants and rhinoceroses

- <u>Impact:</u> Extinction in the near future

- <u>Solution:</u> Unmanned aerial vehicles (UAVs) to spot poachers and animals
  - Equipped with a thermal infrared camera

https://www.cais.usc.edu/projects/machine-learning-for-wildlife-conservation-with-uavs/

Smart Cities

- Changing the way we live in cities
- Boundaries between city and nature
- 100% sustainable buildings

- How about mega cities?

https://www.gemalto.com/iot/inspired/smart-cities

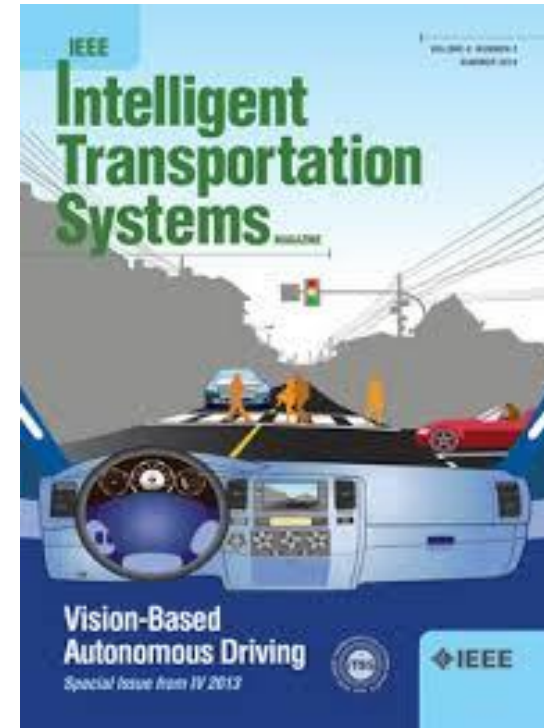http://permanentwalkabout.com/blog/2016/7/5/megacity-new-delhi

Intelligent Transportation Systems

- Intelligent ways of transporting people or goods
- Navigation, route optimisation
- Congestion control
- Communication
- Car sharing

Volkswagen Emissions Scandal

https://en.wikipedia.org/wiki/Volkswagen_emissions_scandal

Conclusions

- In this lecture, we have
  - Reviewed definitions of sustainability
  - Seen cases of how computing professionals can impact the environment
  - Identified fields of computing that have strong relations with sustainability

Additional Material

- "Some Computer Science Issues in Creating a Sustainable World" - http://www.cs.cmu.edu/~io/publications/ieee08-preprint.pdf
- http://www.clickclean.org/
- http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
- http://sustain.stanford.edu/predicting-poverty
- Ted talks:
  - https://www.ted.com/talks/peter_calthorpe_7_principles_for_building_better_cities#t-801679
  - https://www.ted.com/talks/alex_steffen_sees_a_sustainable_future