A Framework for Ethics in Cyber-Physical-Human Systems

Ethical Challenges for Systems & Control
Invited Session
IFAC World Congress
Berlin
July 2020

Pramod P. Khargonekar and Meera Sampath
UC Irvine and SUNY

Ethical Decision Making and Internet

"We didn't take a broad enough view of our responsibility," Marc Zuckerberg

"My experience at Facebook was that there was this very moralistic sense of the mission: of connecting people, connecting the world." Kate Loose

"… morphed into continuous behavior modification on a mass basis, with everyone under surveillance by their devices and receiving calculated stimulus to modify them. It's a horrible thing that was foreseen by science-fiction writers." Jerome Lanier

The Internet Apologizes …

Even those who designed our digital world are aghast at what they created. A breakdown of what went wrong — from the architects who built it.

By **Noah Kulwin**

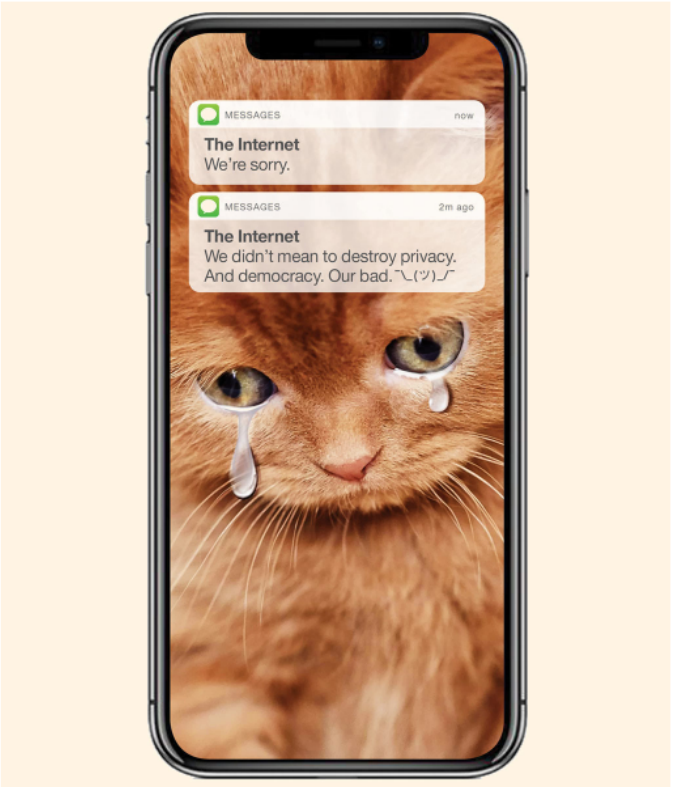
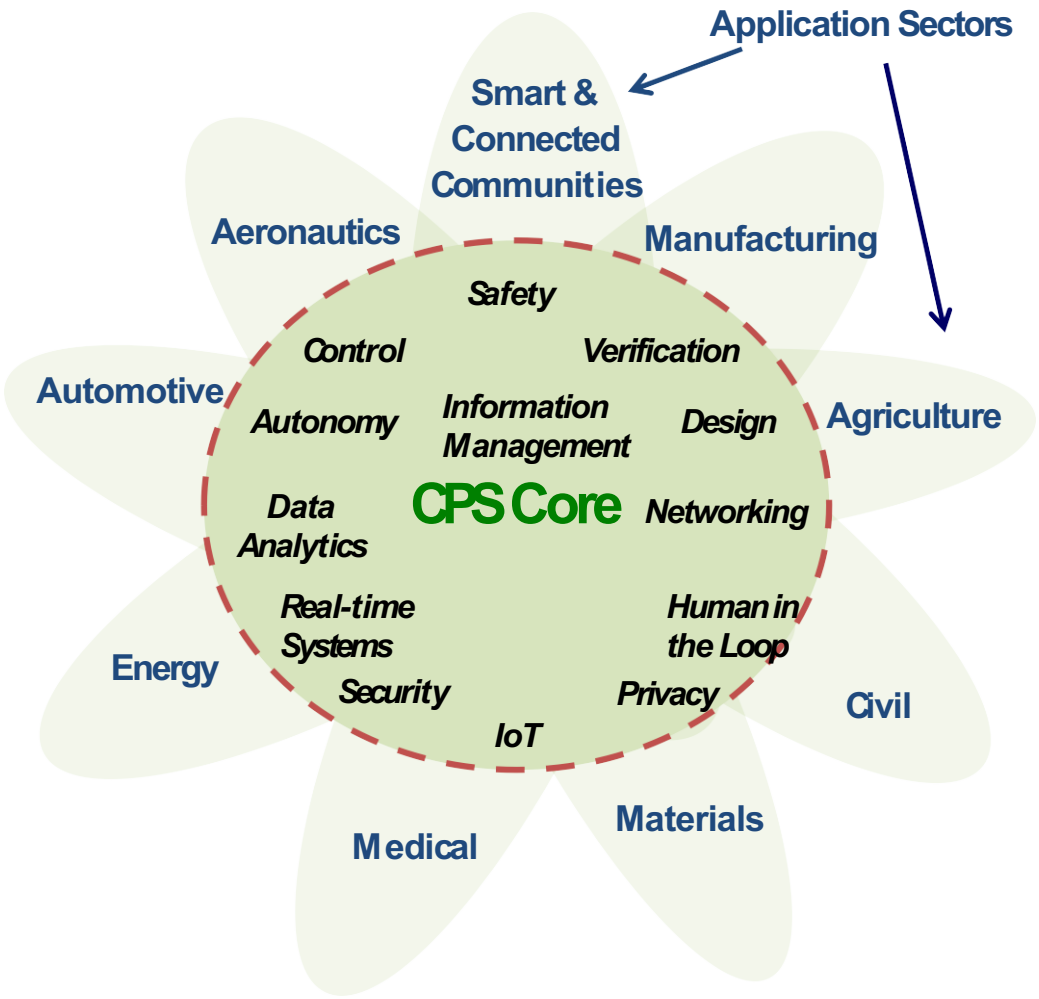


Photo-illustration by Joe Darrow

Source: http://nymag.com/intelligencer/2018/04/an-apology-for-the-internet-from-the-people-who-built-it.html

Cyber-Physical Systems



Application Domains

Transportation

- Faster and safer vehicles (airplanes, cars, etc)
- Improved use of airspace and roadways
- Energy efficiency
- Manned and un-manned

Energy and Industrial Automation

- Homes and offices that are more energy efficient and cheaper to operate
- Distributed micro-generation for the grid

Healthcare and Biomedical

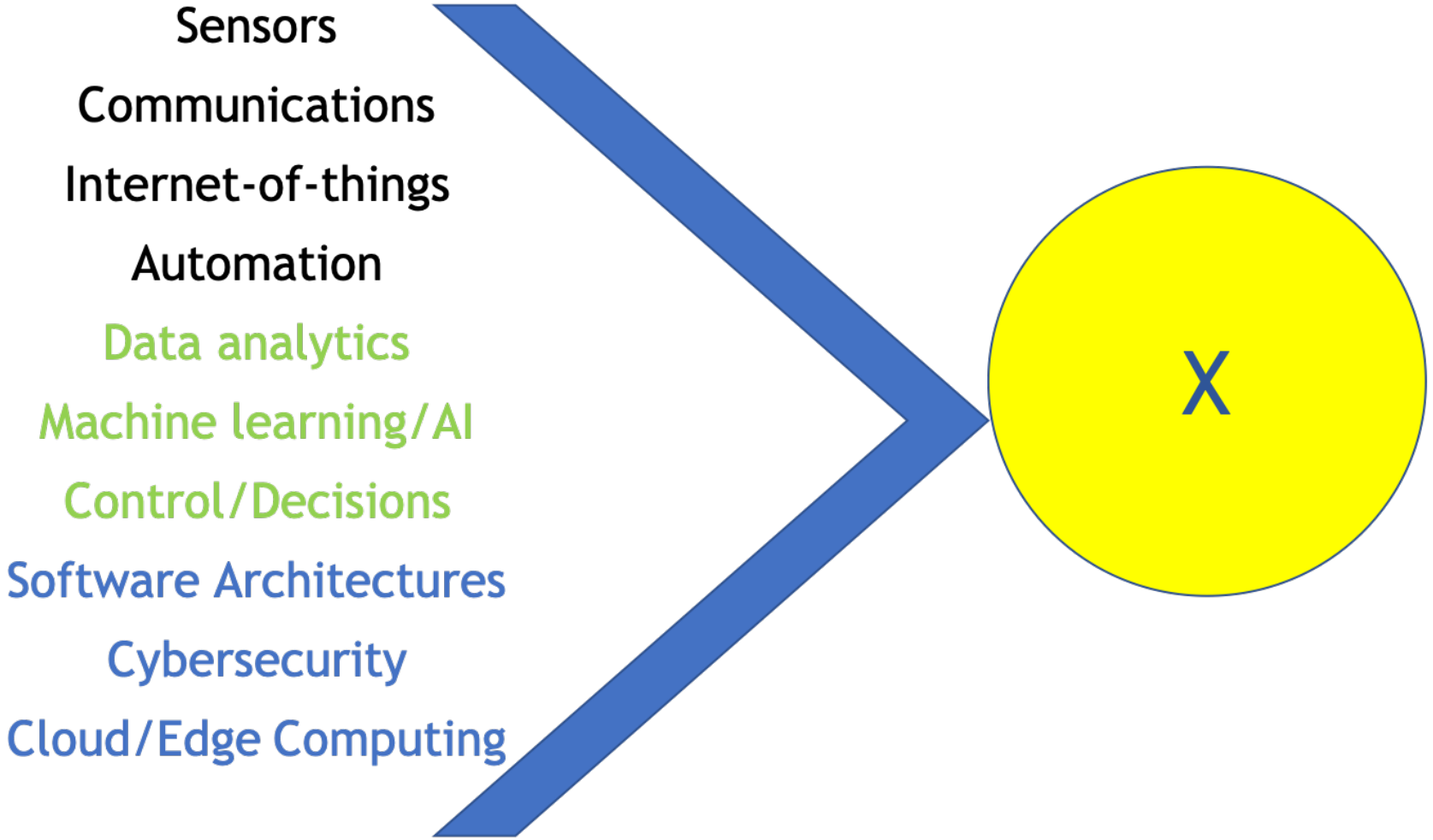
- Increased use of effective in-home care
- More capable devices for diagnosis
- New internal and external prosthetics

Critical Infrastructure

- More reliable power grid
- Highways that allow denser traffic with increased safety

Source: NSF

CPS Meets ML/AI and Leads to Smart Everything



Smart CPHS = Cyber-Physical Systems + ML/AI in interaction with Humans

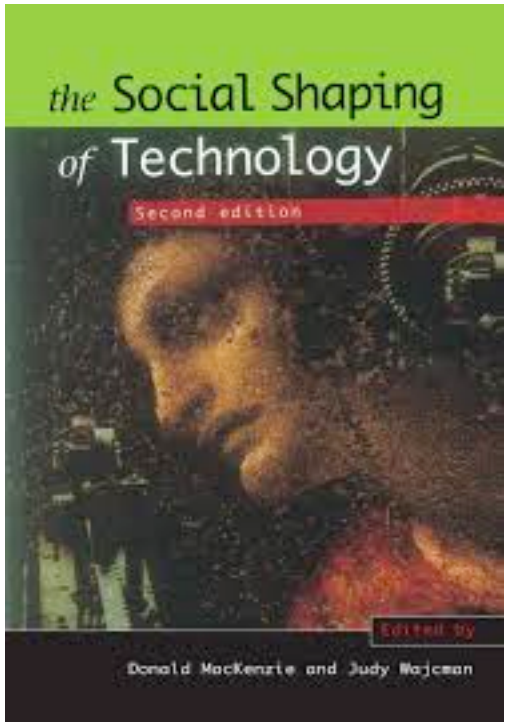
What conceptual frameworks can be used to consider ethical issues as we research, develop, commercialize, and deploy smart CPHS?

Setting the Context

Technological Determinism

"Technologies evolve exogenously, either solely due to scientific advances or following an autonomous development path"

- This is not an accurate depiction of technological development
- Many other factors play important roles:
  - Existing technologies
  - Anticipated future costs and profits
  - State sponsorship,
  - Usage and adoption by society.
  - Social, political, economic systems
  - **Choices by individuals and organizations**



We must consciously fight tendency toward technological determinism and affirm that we have choices to make

MacKenzie and Wajcman (1999), Noble (1978), Winner (2010)

Emerging and Revolutionary Technologies

Table 1. Stages of an open technological revolution

	Introduction	Permeation	Power
Devices	Esoteric	Standardized	Leveraged
Users/Beneficiaries	Few	Select	Many
Understanding	Elite	Trained	Common
Cost per Use	High	Medium	Low
Usefulness	Limited	Moderate	High
Integration into Society	Minor	Moderate	Major
Social Impact	**Marginal**	**Noticeable**	**Significant**

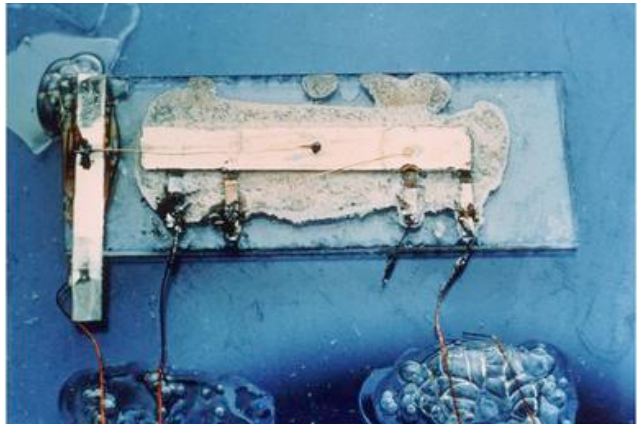
ATE: Anticipatory Technology Ethics due to Brey

Emerging Technology Ethics

Moor (2005), Brey (2012)

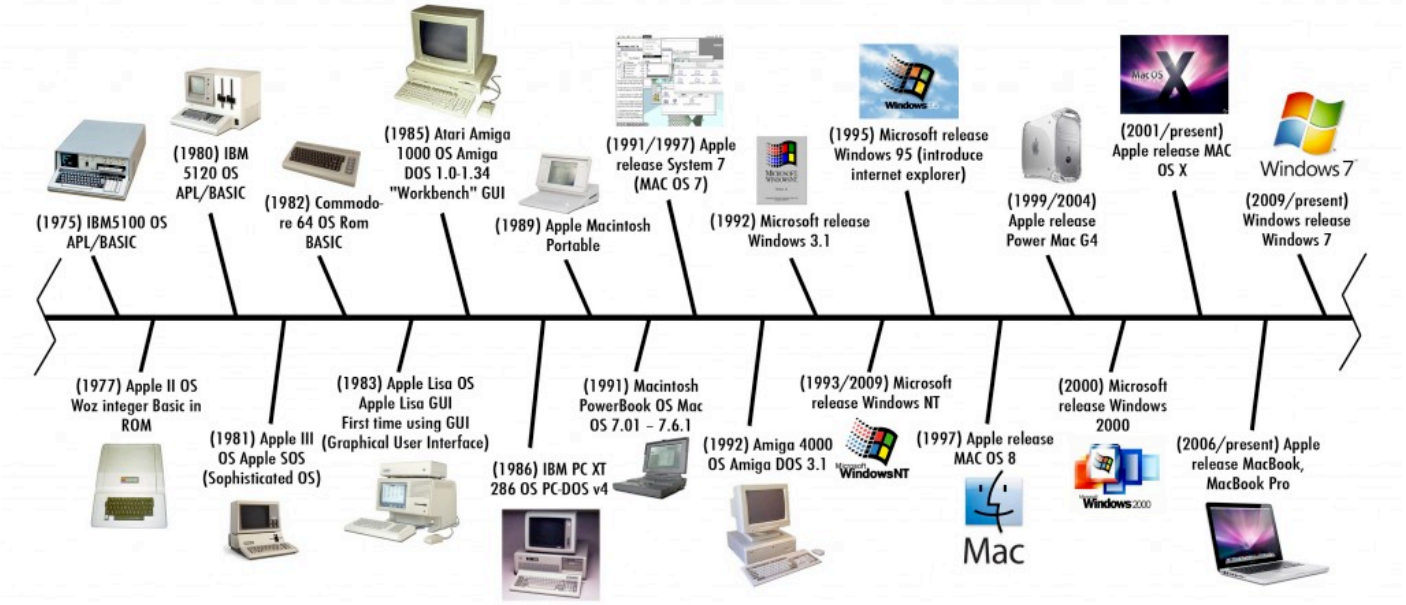
Modern Computing from Introduction to Power Stage

John Bardeen, William Shockley and Walter Brattain at Bell Labs, 1948



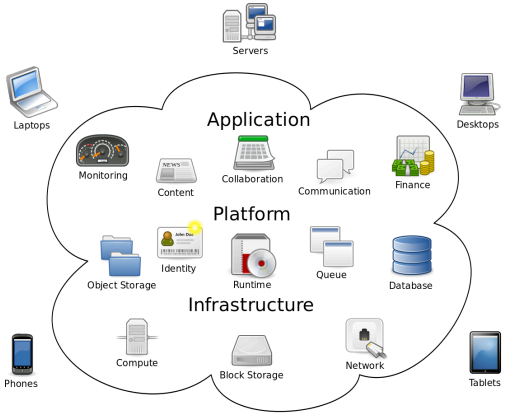
Jack Kilby's original integrated circuit

IBM System/360



Evolution of Personal Computers

Evolution of mobile



Cloud computing

Ethics in AI

Sources: IEEE, Berkman Klein Center, Harvard

Our Framework

Increasing impact of ethical issues with technology maturity and adoption (Moor's law)

Stages of Technology Development

Mature

Developing

Early Stage

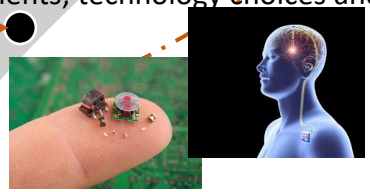
Basic Research

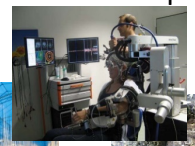
Ongoing enforcement/compliance/adherence, transparency, vigilance and refinement (safety, environment, health, security)

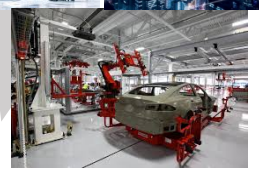
Social and environmental implications and unintended consequences of large-scale adoption (human rights, safety, empowerment, shared prosperity, accountability) and required actions (precautions, guidelines, regulations)

Commercial, social and environmental implications of technology (accessibility, affordability, equitability, ownership, pricing, unintended consequences); technology/application choices

Technology forecasting, convergence, thought experiments; technology choices and guard rails







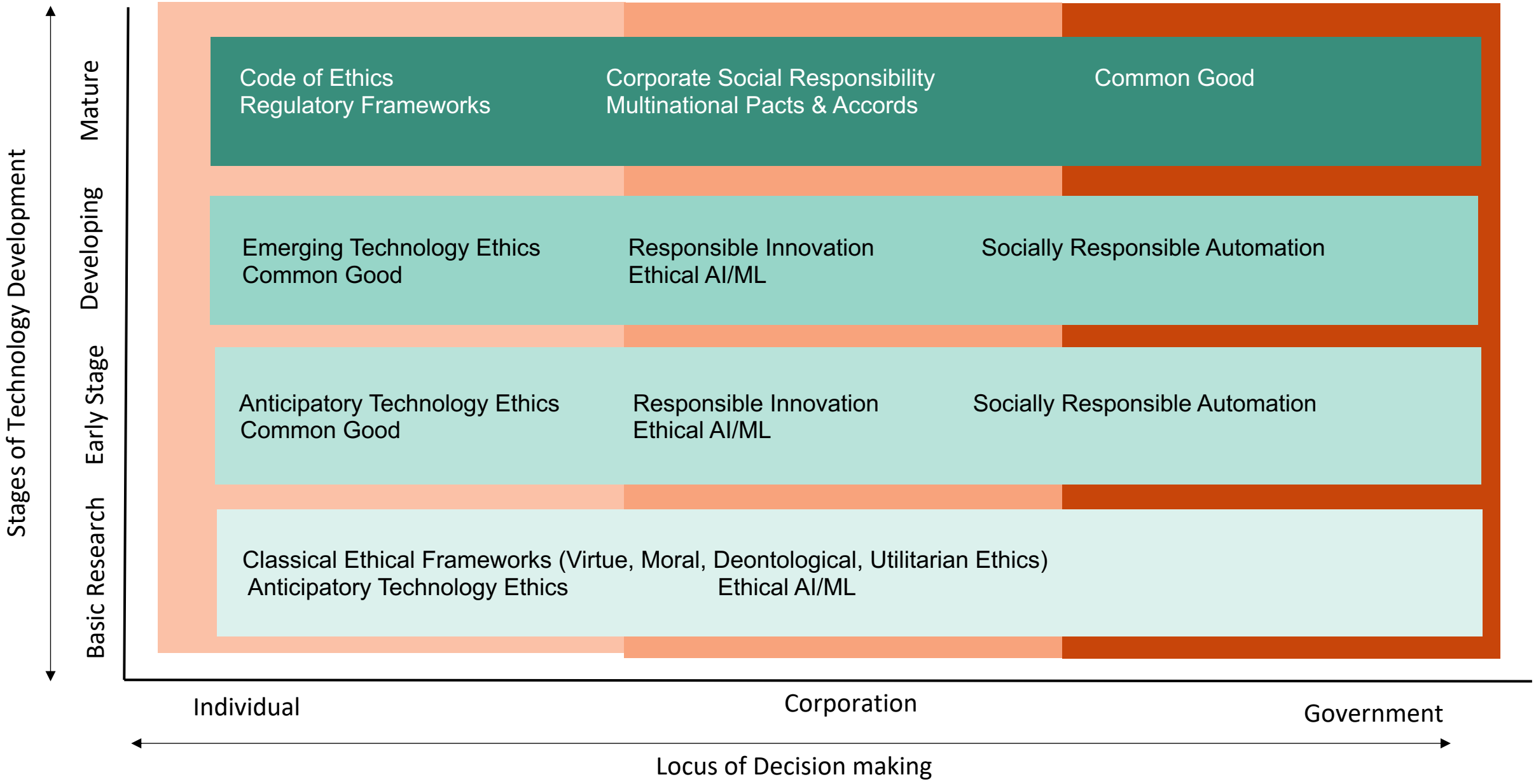
Individual

Corporation

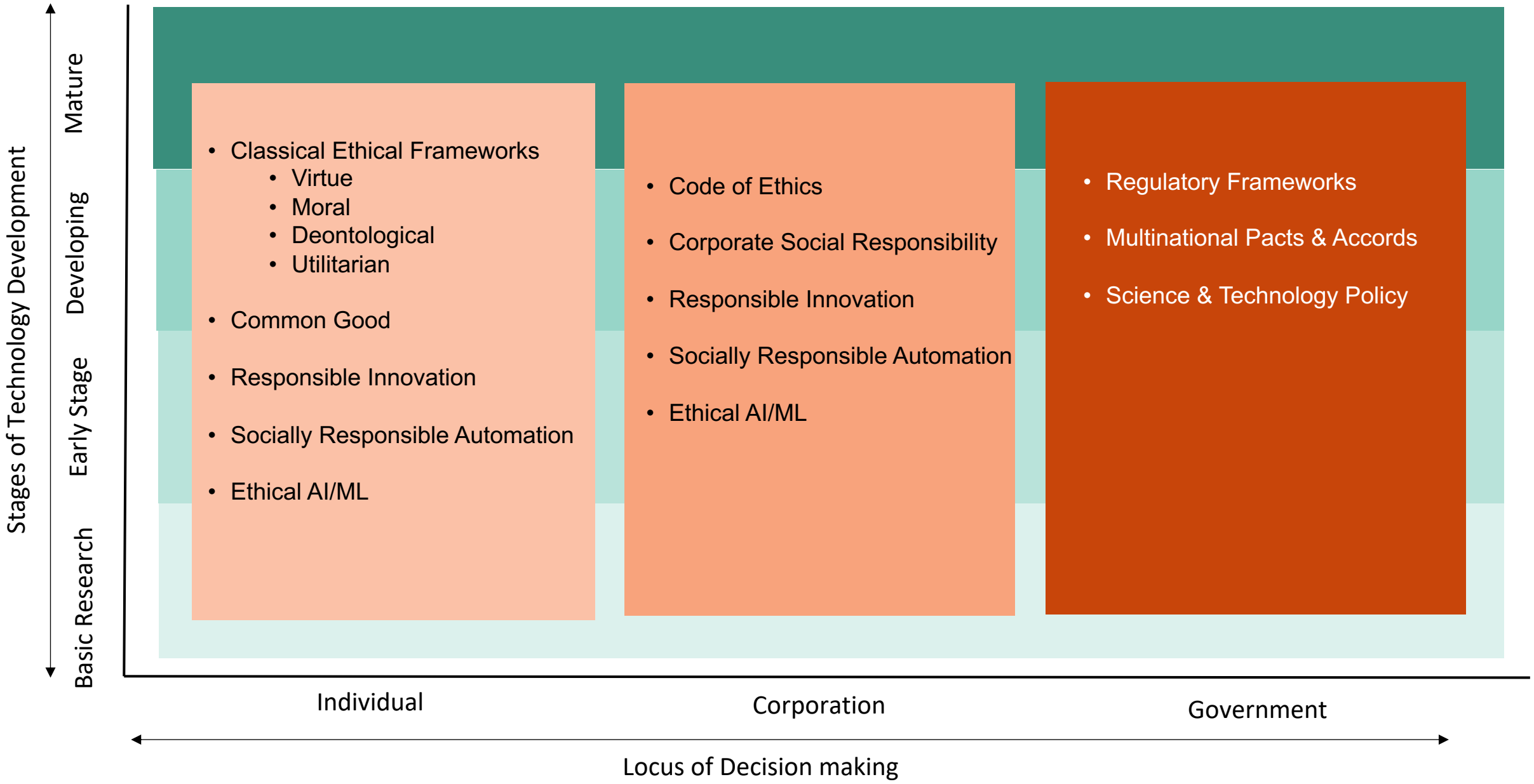
Government

Locus of Decision making

Technology Maturity: Ethical Frameworks



Locus of Decision Making: Ethical Frameworks



Four Examples

- Boeing and 737 Max
- Autonomous and connected cars
- Autonomous greenhouse technologies
- Nano-sensors and nano-robots in human bodies

Conclusions

- Smart CPHS will increasingly lead to high impact ethical problems
- Our two-dimensional framework is aimed at a way to think about these problems
- IFAC community has a critically important role through research, education and public outreach
- Let us work together to bring ethics and ethical decision making into CPHS

Thank you!