pervasive, ambient, ubiquitous:

the magic of radio

Lara Srivastava
ITU New Initiatives Programme

European Commission Conference
"*From RFID to the Internet of Things*"

Bruxelles, 6th March 2006

International Telecommunication Union

trends toward ubiquity

- Trends in the ICT market point to the preponderance of radio technologies
- Tremendous growth of mobile cellular and wireless broadband networks
  - 2 billion mobile phone users today
- Importance of always-on access and availability of communications and information anywhere, anytime
- … making technology "ubiquitous"

ITU

lara.srivastava@itu.int

radio, radio everywhere

- The densest radio systems in the world are terrestrial radio and cellular
  - the ratio of radios to humans is nearing 1 to 1
- But we are soon entering a new era:
  - in which this ratio could exceed 1000 to 1
- Thus, radios would be all around us, becoming "ambient" in the environment
- … thereby radically transforming the role of technology

radio in on the internet of things

- We have oft talked about anytime and anywhere connection by anyone
- But it can go further still through radio technology:
  - By **"anything"…**
- This is the vision underlying the concept of a "network of things or objects"
  - Giving each thing its own "identity" in cyberspace
- In other words: the internet now connects computers to one another, but imagine if it could also connect computers to things – a whole new dimension?
  - Is this the dawn of an **"Internet of things"**?

RFID: a key enabler

- The term RFID consists of two parts: *radio-frequency* (RF) and *identification* (ID)
- RFID systems allow us to identify individual "things" in the environment
    - **typical system made up of reader, tag & middleware**
- RFID systems provide a sort of "map" of the real world in the virtual world
- As such they can wirelessly monitor objects in real-time, without necessarily having line-of-sight
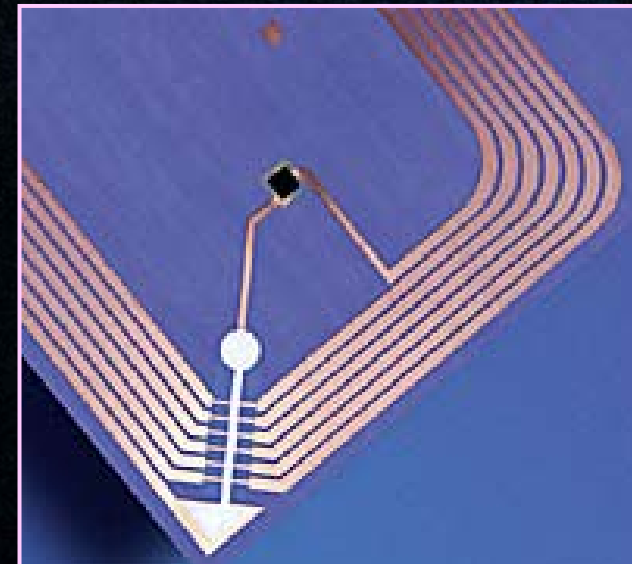
a big idea but not a new one

- ## It's all about radio after all (19th century)

  – Combined with radar (discovered 1922 by Leo Young)

  – RFID said to be discovered ca. 1948, in a landmark paper by H. Stockman

History of RFID: Over the decades

Decade	Event
1940-1950	Radar defined and used. Major World War II development efforts. RFID invented in about 1948.
1950-1960	Early explorations of RFID technology. Laboratory experiments.
1960-1970	Development of the theory of RFID. Early field trials.
1970-1980	Explosion of RFID development. Tests of RFID accelerate. Early adopter implementation of RFID.
1980-1990	Commercial RFID applications enter the mainstream
1990-2000	Emergence of standards. RFID more widely deployed.
2000-2010	Innovative applications emerge. Combination of RFID with personal mobile services. Subcutaneous RFID emerges for animals, humans. RFID becomes part of daily life.

big idea in a small package

Tag/Transponder
located somewhere within this dark dot
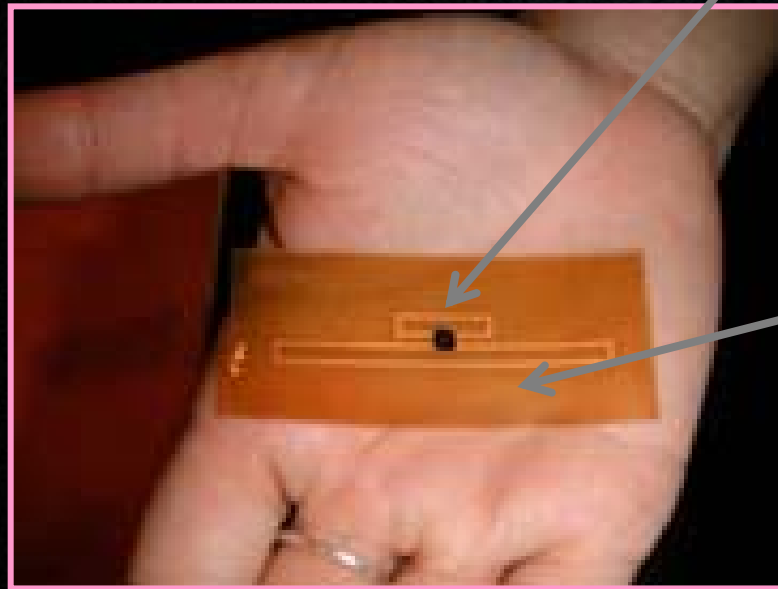
Some Hi-tech
Orange Material
For Display

Interrogator
(...waiting back stage)

and shrinking all the time

approx. 50mm

- **µ-Chip** (Hitachi)
  - World's smallest at 0.4 mm x 0.4mm x 0.15mm
  - No power source (no battery)
  - Reading distance: approx 30 cm
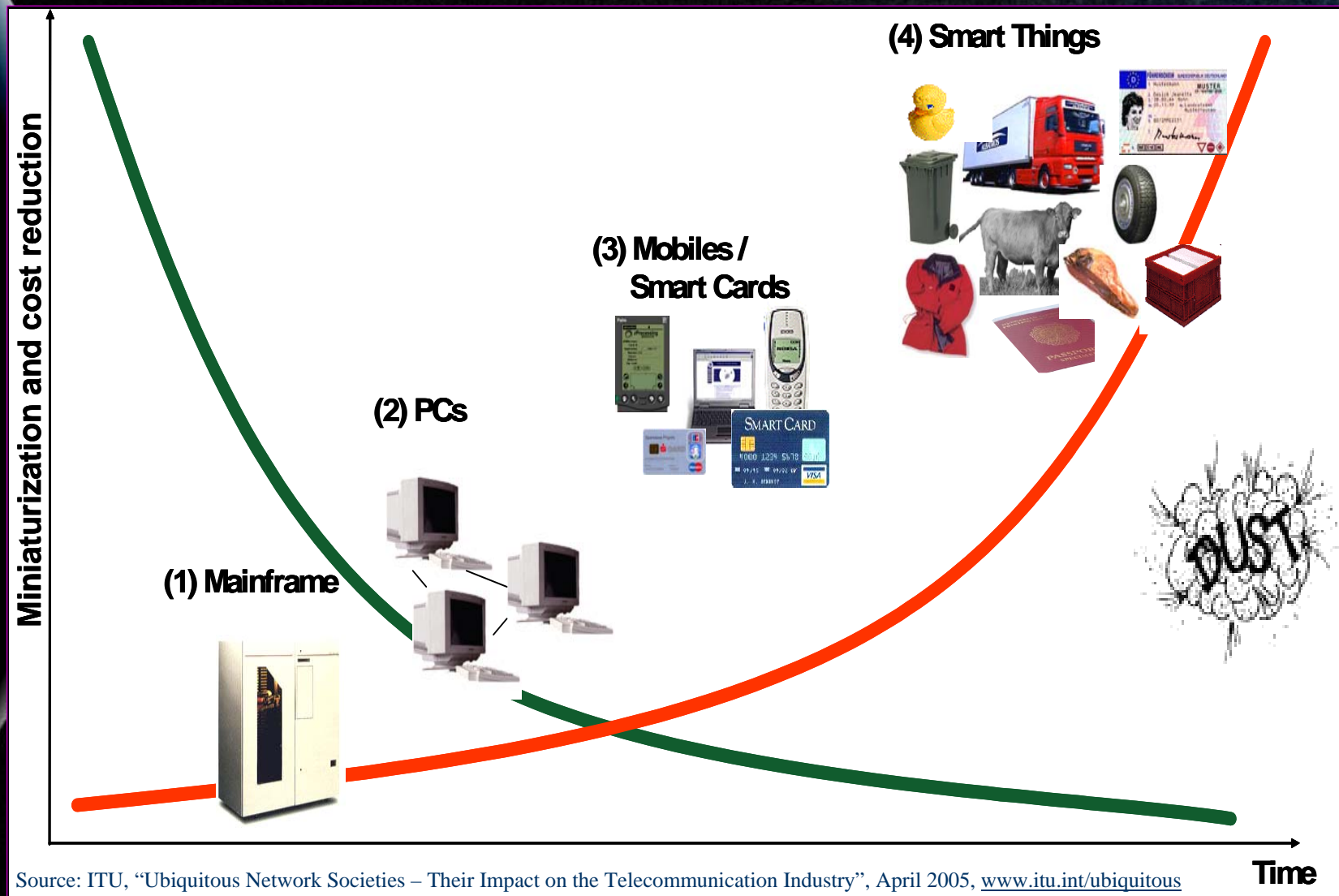- Scientists now working on developments to shrink computing power further
  - Nanotechnology and the disappearing processor
  - One day "**smart dust**"?
- Far from science fiction, it's bordering on science fact!
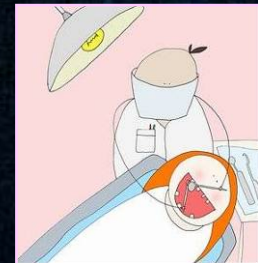 - MIT, Berkeley etc… working on autonomous sensing and communications under a square millimetre
- The linking of tinier and tinier things will increase network communications at a staggering scale

# network connections multiply, as size and cost shrink

(4) Smart Things

(3) Mobiles / Smart Cards

(2) PCs

(1) Mainframe

Miniaturization and cost reduction

Time

# "the magic of things" yielding a plethora of new applications

RFID and sensors: complementary technologies

- **Sensors:** *enable detection of environmental status and sensory information*

  - in combination with sensors, RFID can better track the status of things, e.g. their temperature, the presence of bacteria etc…

  - they can replace human senses to monitor the environment

  - as such, they act as a further bridge between the physical and virtual worlds
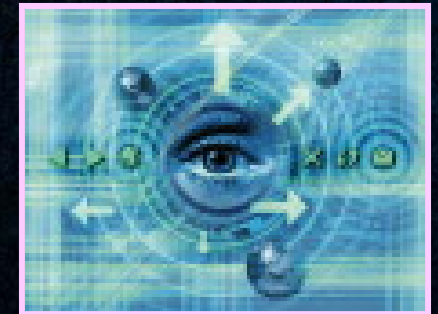
# So what if things could think (ambient intelligence)?
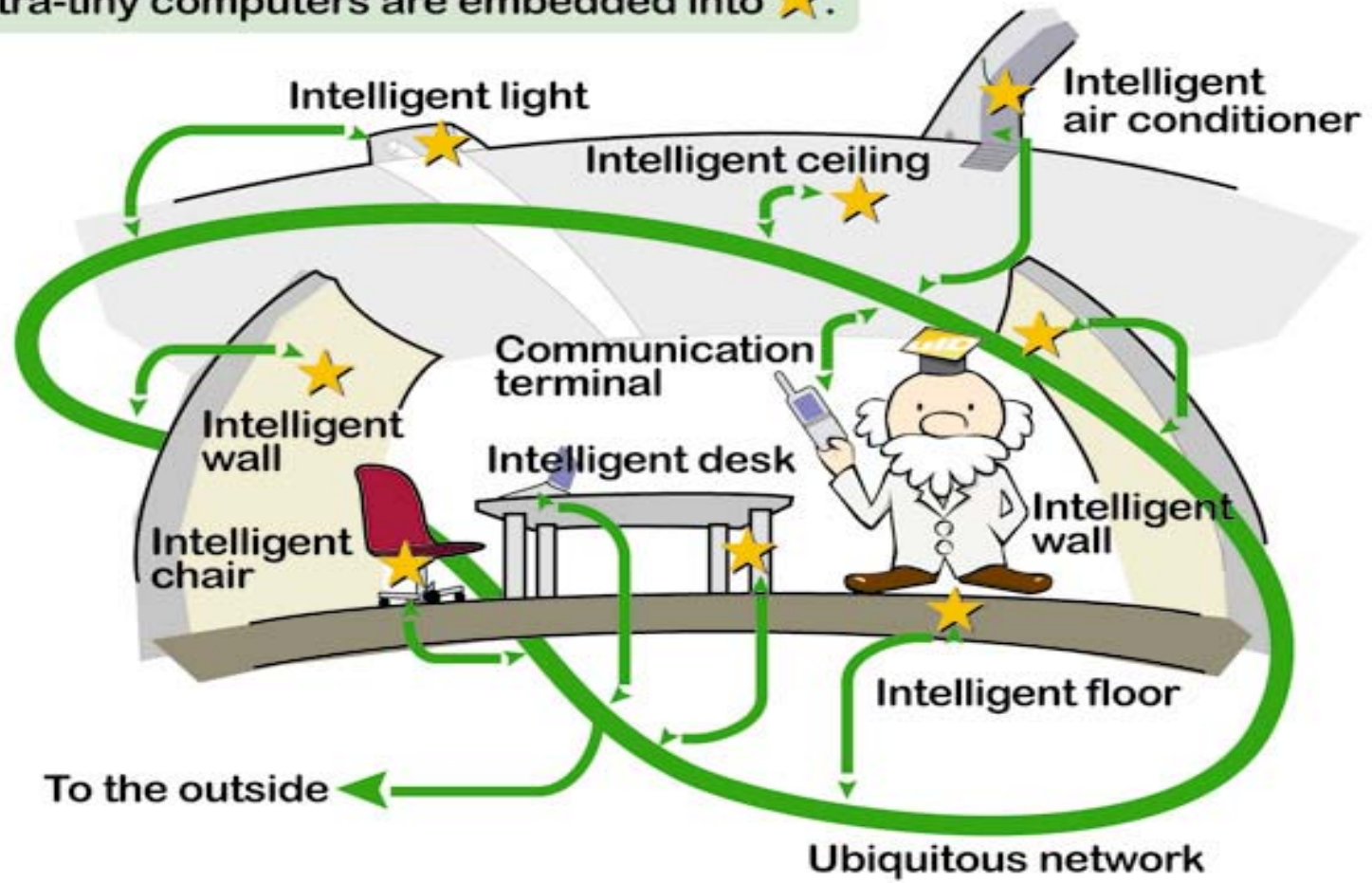
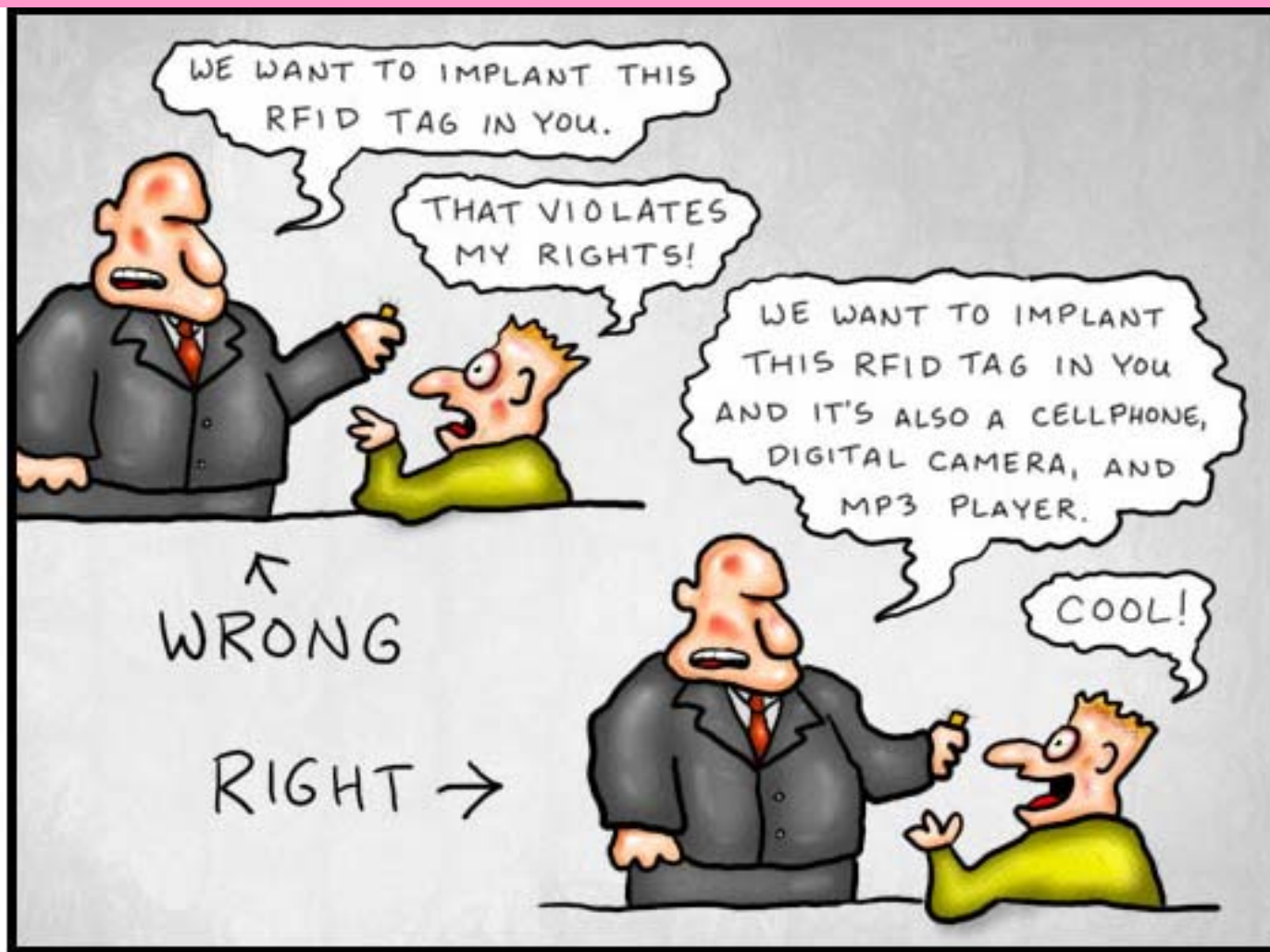# their thinking and talking would occur invisibly in the background

- Who controls information on the tags?
- Who has access to it and when?
- RFID has already been plagued by delays due to consumer concerns
  - e.g. Benetton
- Public sector has begun addressing the problem
  - EU Data Protection WP, Japan's RFID Guidelines
- How to avoid a privacy divide?
  - The phenomenon of the supermarket loyalty card
- There remains a lack of clarity
  - How to convince users to take up the technology amidst concerns over privacy
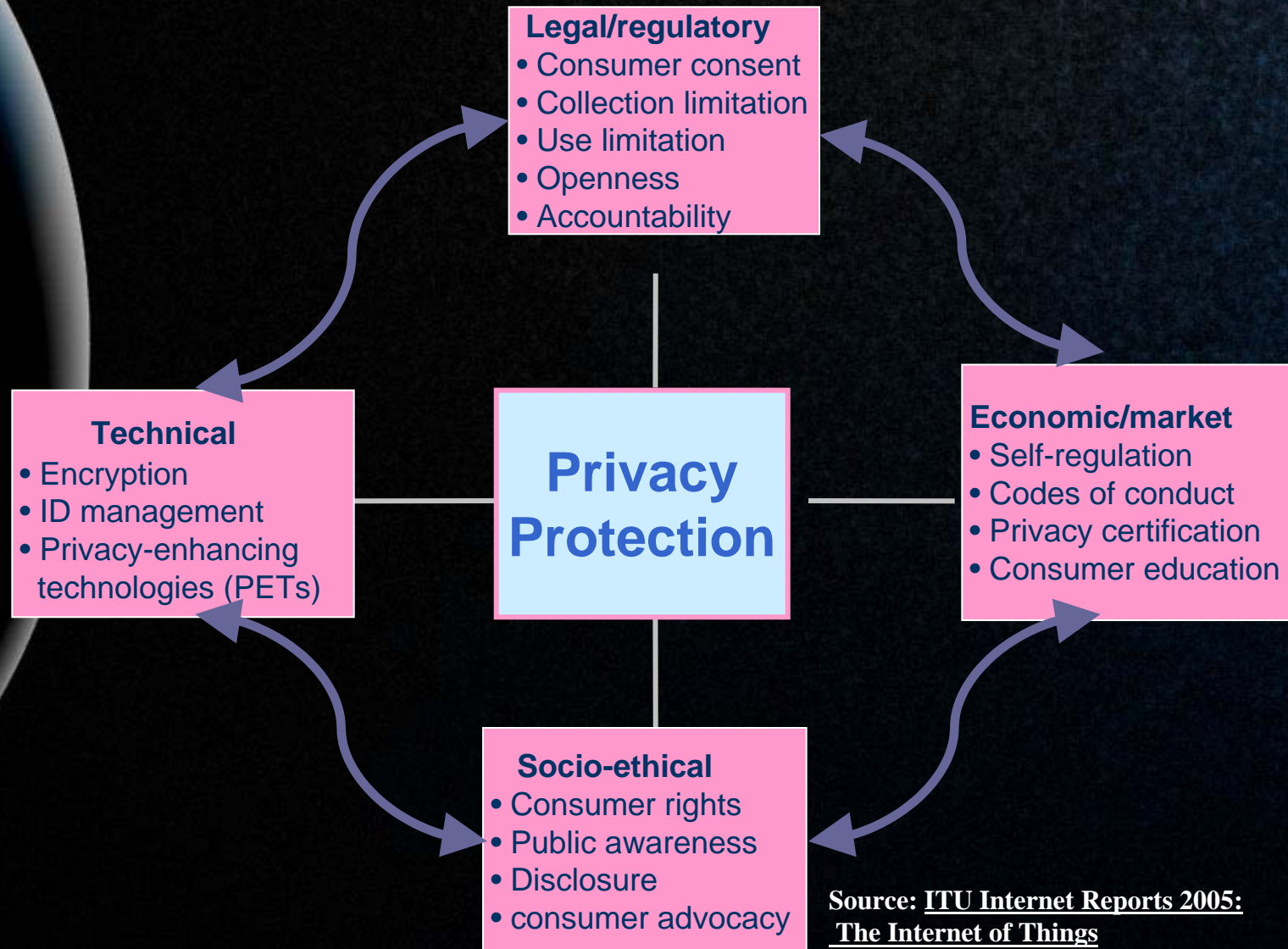
demand side: the benetton boycott
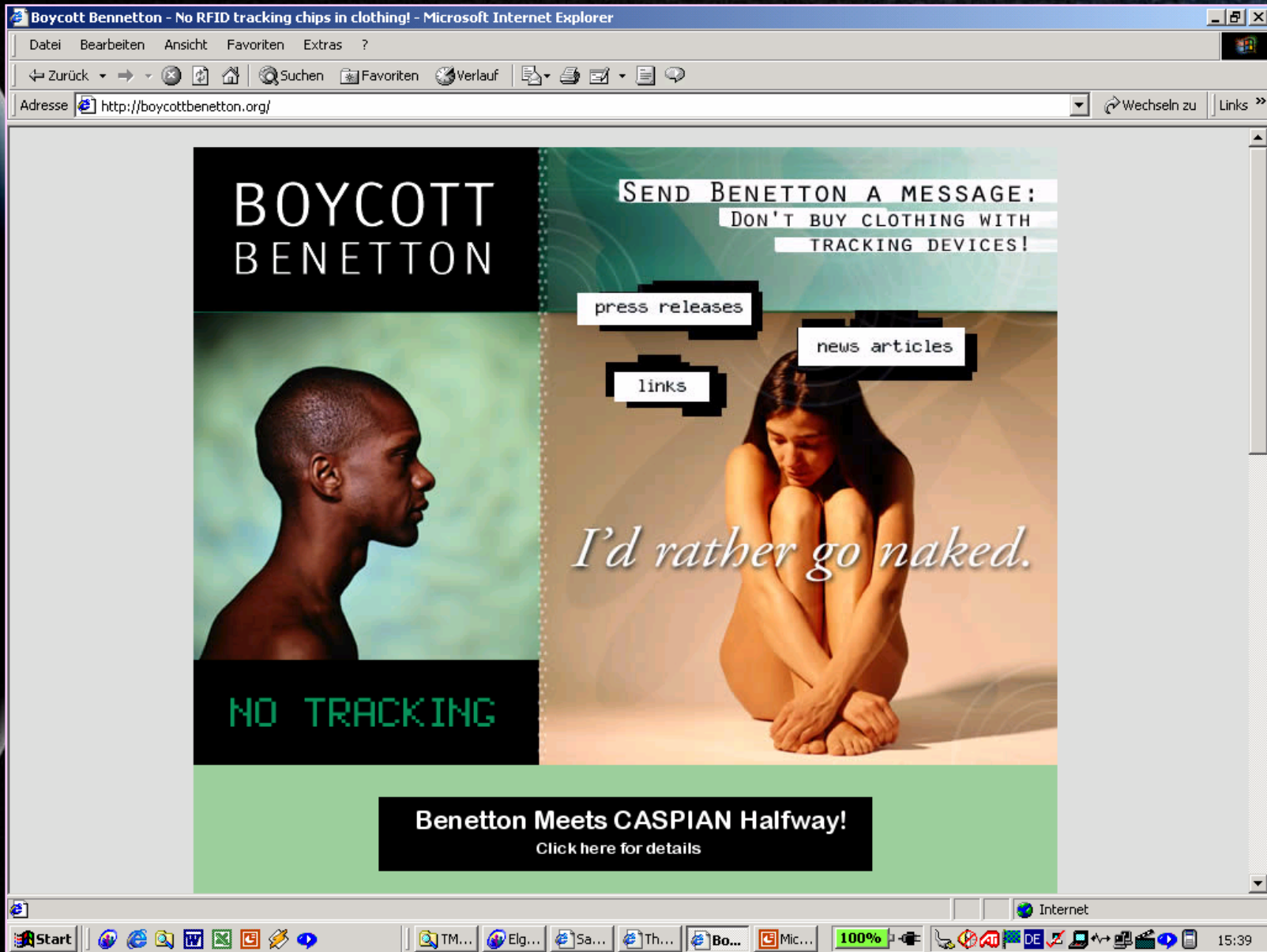
supply side:
is this the whole answer?
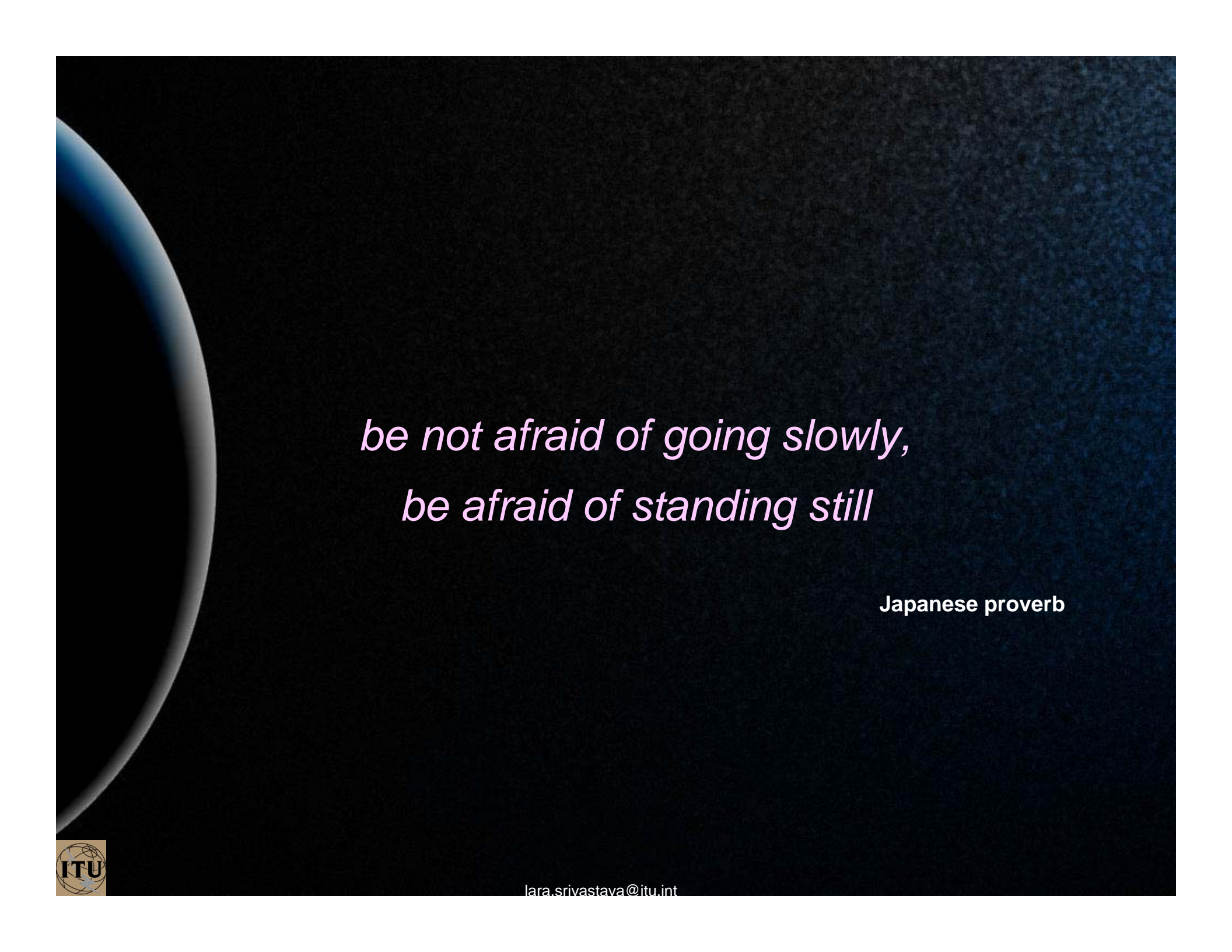
privacy in <u>all</u> its facets should be built into the <u>design</u> of technology

Legal/regulatory
- Consumer consent
- Collection limitation
- Use limitation
- Openness
- Accountability

Technical
- Encryption
- ID management
- Privacy-enhancing technologies (PETs)

Privacy Protection

Economic/market
- Self-regulation
- Codes of conduct
- Privacy certification
- Consumer education

Socio-ethical
- Consumer rights
- Public awareness
- Disclosure
- consumer advocacy

Important challenges

- Consumer protection
  - e.g data protection, privacy - also cybersecurity & spam
- Standardization at a global level
  - Standardization remains fragmented
    - not only in networking protocols, but also for tag formats (EPC, uCode…)
    - standardization for authentication and privacy also needed
  - Need for global standardization called for at ITU Workshop on RFID: Systems and Services (Feb 14-15th 2006)
- Governance of Resources
  - Who owns the identifiers?

be not afraid of going slowly,
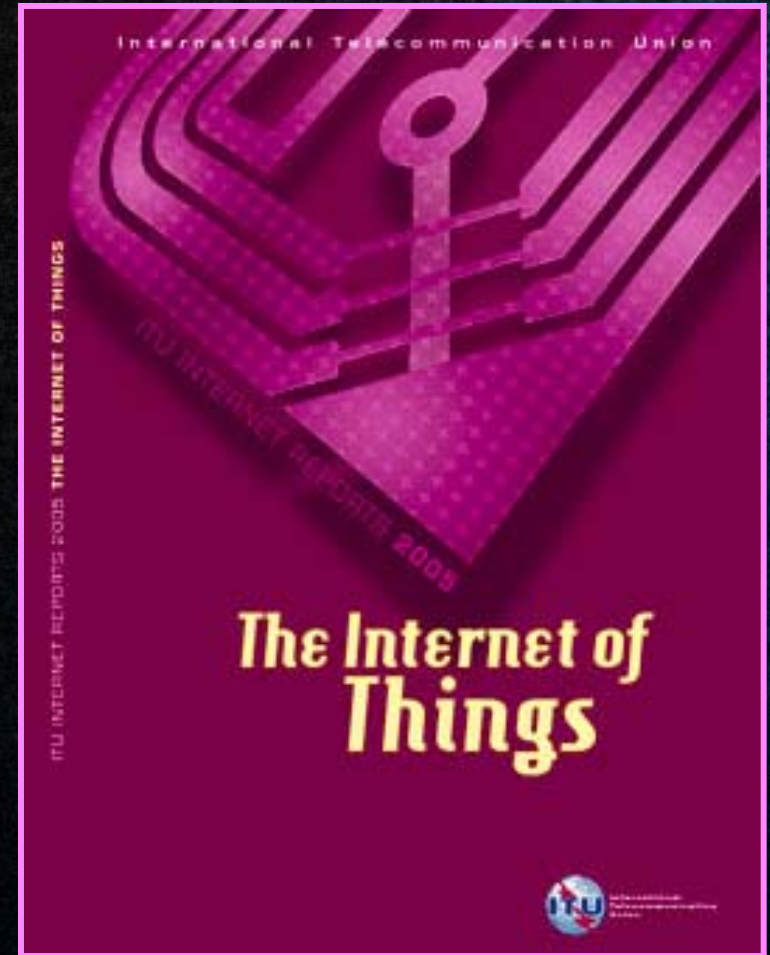
be afraid of standing still

Japanese proverb

T H A N K S !

www.itu.int/internetofthings

ITU Internet Report 2005 on "The Internet of Things" launched at the *World Summit on the Information Society*, Tunis, November 2005

lara.srivastava@itu.int