Pengenalan Persoalan-Persoalan Tingkat Lanjut dalam Pemrograman

Tim Pengajar
IF1210 Dasar Pemrograman
Sem. 2 2019/2020

Tujuan

- memahami kembali big picture dari materi IF1210-Dasar Pemrograman
- memahami batasan pemrograman dan kaitannya dengan kompleksitas algoritma
- memahami posisi dan kebutuhan pemrograman di lingkungan STEI, dan kaitannya dengan prodi di STEI
- termotivasi untuk berinovasi dalam isu-isu terkini (RI 4.0) melalui pemrograman

Topik

- Review materi kuliah IF1210
- Kompleksitas algoritma dan persoalan-persoalan yang “tidak biasa”
- Pemrograman di prodi di lingkungan STEI
- Pemrograman dan Revolusi Industri 4.0

Bagian 1:
Review Materi
IF1210 Dasar Permorgraman

Review Materi IF1210 (1)

- Konsep-konsep dasar dalam berpikir komputasi:
  - Dekomposisi
  - Pengenalan pola
  - Abstraksi dan generalisasi pola
  - Perancangan algoritma

Review Materi IF1210 (2)

- Pengenalan dunia pemrograman:
  - Sejarah
  - Belajar pemrograman vs belajar bahasa pemrograman
  - Paradigma pemrograman
  - Taksonomi bahasa pemrograman
  - Artefak dan lingkungan pemrograman
  - Berbagai area pemrograman

Review Materi IF1210 (3)

- Pengenalan dunia pemrograman:
  - Skala dan kompleksitas program
  - Taksonomi dan level programmer
  - Programmer vs software engineer

Analogi Membangun software vs membangun program [kecil]

Software diibaratkan pencakar langit

vs

Program [kecil] diibaratkan rumah kecil

Pemrograman Fungsional

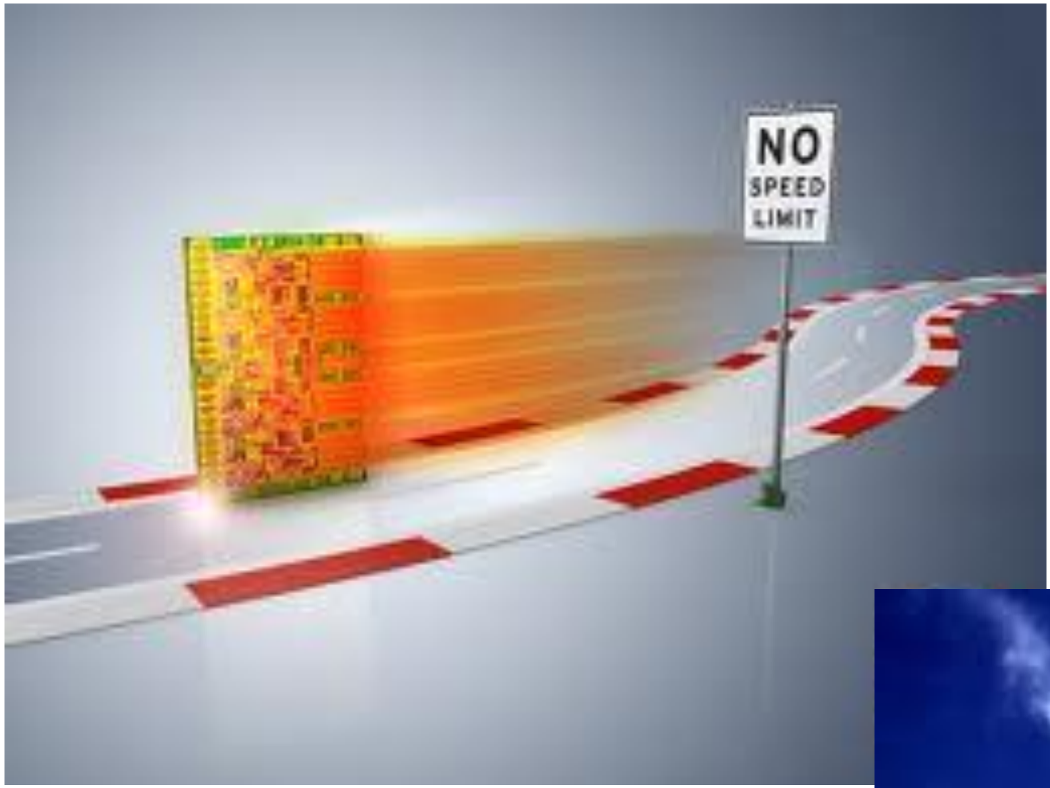
- Konsep dasar
- Dekomposisi masalah dan abstraksi dengan fungsi
- Analisis rekurens
- Struktur data: list of elemen sederhana

Pemrograman Prosedural

- Dekomposisi masalah, abstraksi, dan pengenalan pola dalam paradigma prosedural
- Standar koding
- Skema standar:
  - Skema validasi
  - Skema pengulangan dan pemrosesan sekuensial
  - Struktur data array dan skema terkait: traversal, searching, pencarian nilai ekstrim, sorting
  - File eksternal: membaca, menulis, skema konsolidasi, skema merging

Sampai di mana IF1210?

- Kategori Program:
  - Application Software
- Bahasa:
  - Haskell, Python
- Paradigma:
  - Fungsional, Imperative/Prosedural
- Skala program:
  - Program kecil
- Kompleksitas program:
  - Algoritma dasar


NO
SPEED
LIMIT

Bagian 2:
Kompleksitas Algoritma

Tujuan

- Mengenal beberapa persoalan yang lebih kompleks dibanding materi IF1210,
- Memahami tentang kompleksitas algoritma.

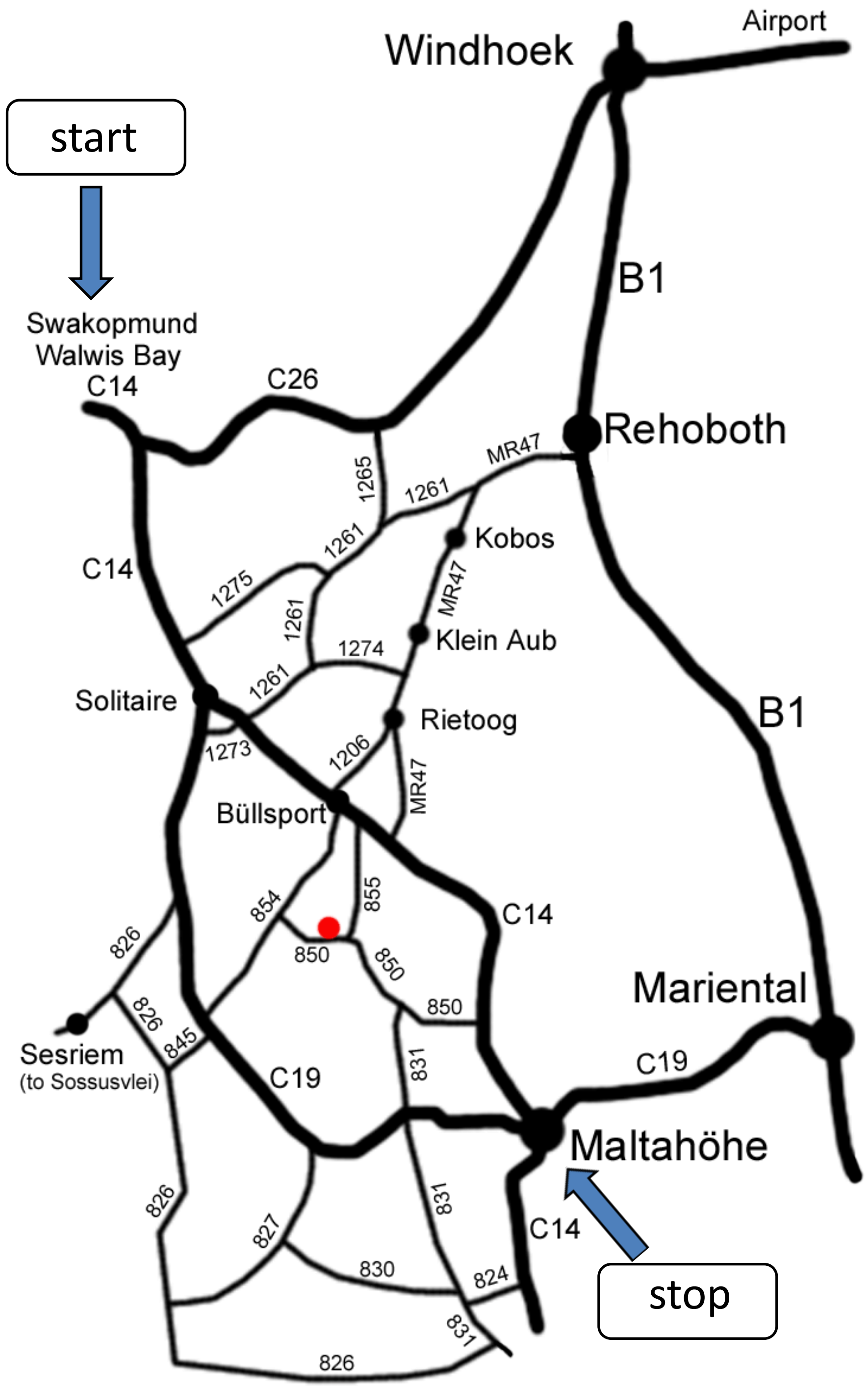
Telah dipelajari...

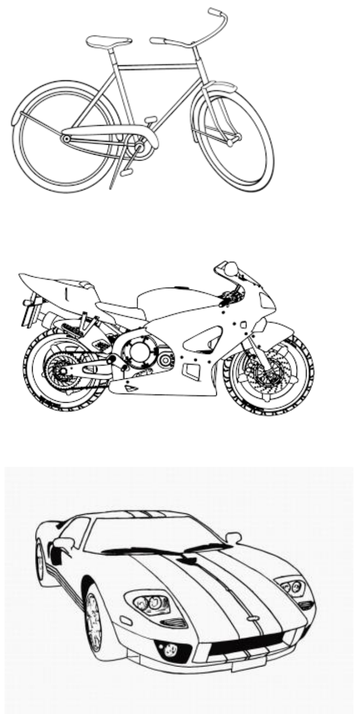
- Struktur array (tabel)
  - Algoritma traversal
  - Algoritma sequential searching
  - Algoritma pencarian nilai ekstrim
  - Algoritma sorting: counting sort, selection sort, insertion sort, bubble sort

- Bagaimana jika datanya sangat... sangat besar?
- Bagaimana jika strukturnya rumit (dalam bentuk *tree* atau *graph*)
- Apakah ada persoalan yang tidak dapat diselesaikan?

Pengantar Kompleksitas Algoritma (1)

- Algoritma harus dapat menyelesaikan persoalan dengan “benar”
- Untuk algoritma dengan persoalan yang besar dan kompleks, dibutuhkan **algoritma yang eficient** (eksekusi cepat, kapasitas memory rendah)
- Kecepatan algoritma dapat diukur dengan:
  - Waktu eksekusi program (tergantung lingkungan eksekusi)
  - Analisis kompleksitas


start
stop
Windhoek
Airport
B1
Rehoboth
Swakopmund
Walwis Bay
C14
C26
1265
1261
MR47
Kobos
1275
Klein Aub
1274
Solitaire
Rietoog
1273
1206
Büllsport
854
855
826
850
C14
Mariental
Sesriem
(to Sossusvlei)
845
C19
831
Maltahöhe
827
830
824
826



Pengantar Kompleksitas Algoritma (2)

- Untuk sebuah table (array) bilangan integer terurut membesar dengan ukuran elemen n,
  - berapa “waktu” yang diperlukan untuk mendapatkan nilai terkecil jika n=1, 2, 3, ... 10000000? → konstan
  - Berapa “waktu” yang diperlukan untuk menemukan bilangan tertentu dengan *binary search* → logaritmik
  - Berapa “waktu” yang diperlukan untuk mencetak seluruh elemen → linear

Selection Sort (Algoritma)

```
procedure MAXSORT (var T : TabInt; N : integer);
(* mengurut tabel integer [1..N] terurut mengecil dgn maksimum suksesif *)

(* Kamus Lokal *)
var
    i : integer;        (* indeks untuk traversal tabel *)
    Pass : integer;     (* tahapan pengurutan *)
    Temp : integer;     (* memorisasi harga untuk penukaran *)
    IMax : integer;     (* indeks, di mana T[Pass..N] bernilai maksimum *)

(* Algoritma *)
begin
   if (N > 1) then
   begin
        for Pass := 1 to N-1 do
        begin
             (* Tentukan Maximum [Pass..N] *)
             IMax :=  Pass;
             for i := Pass+1 to N do
                     if (T[IMax] < T[i] ) then
                             IMax :=  i;
             (* T[IMax] adalah maximum T[Pass..N] *)
             (*Tukar T[IMax] dengan T[Pass] *)
             Temp    := T[IMax];
             T[IMax] := T[Pass];
             T[Pass] := Temp;
             (* T[1..Pass] terurut: T[1] >= T[2] >= ... >= T[Pass] *)
        end;
   (* Seluruh tabel terurut, T[1] >= T[2] >= ... >= T[N] *)
   end;
```

Cari indeks dgn nilai maksimum (di bagian tabel yang belum terurut)

Tukarkan elemen pada indeks maksimum dengan elemen terujung dari bagian tabel yang belum terurut

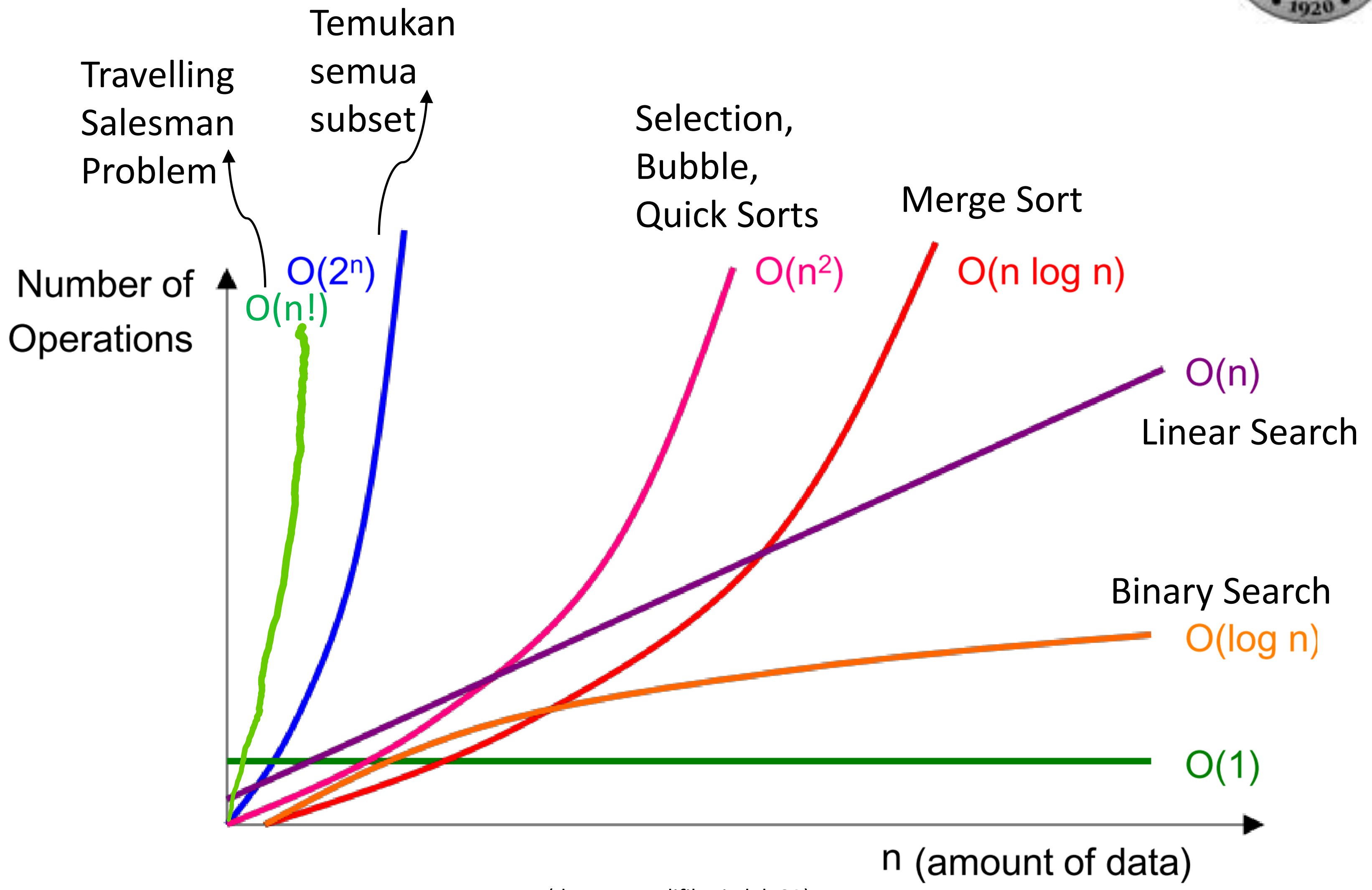
Berapa kompleksitas algoritma selection sort?

- Berapa kali operasi perbandingan dilakukan jika n = 2, 3, 4, ... 100000?
- Selection sort memiliki kompleksitas quadratic (n^2)

Order of complexity

- Untuk jumlah data (n) yang sangat besar, kita mengekspresikan banyaknya operasi sebagai “the order of complexity” atau disebut **kompleksitas algoritma**.
- Direpresentasikan sebagai notasi Big-O.
  - Jumlah operasi = n $\rightarrow$ $O(n)$
  - $n/5 + 7$ $\rightarrow$ $O(n)$
  - $3n + 15$ $\rightarrow$ $O(n)$, **linear**
  - $5n^2 + 2n$ $\rightarrow$ $O(n^2)$, **quadratic**
  - $7(\log_{10}n) + 3$ $\rightarrow$ $O(\log n)$, **logaritmic**

Perbandingan Fungsi Big-O



(C) 2010 Thomas J Cortina, Carnegie Mellon University (dengan modifikasi oleh SA)

CHURCH-TURING THESIS

Prosedur apapun yang *well-defined* yang dapat ditangani dan dilakukan oleh pikiran manusia dan pensil/kertas, dapat dilakukan dengan komputer dijital konvensional yang tidak memiliki batasan memory

Kategori Persoalan Computing

- mudah dikerjakan (*tractable*) dengan solusi yang efisien dalam waktu yang wajar → polynomial
- tidak mudah dikerjakan (*intractable*) → exponential (2^n), polynomial dengan derajat tinggi (N^{10})
- dapat diselesaikan dengan pendekatan tetapi tidak optimal(*solvable aproximately*, *but not optimally*)
- belum memiliki solusi yang efisien
- tidak dapat diselesaikan (*not solvable*)

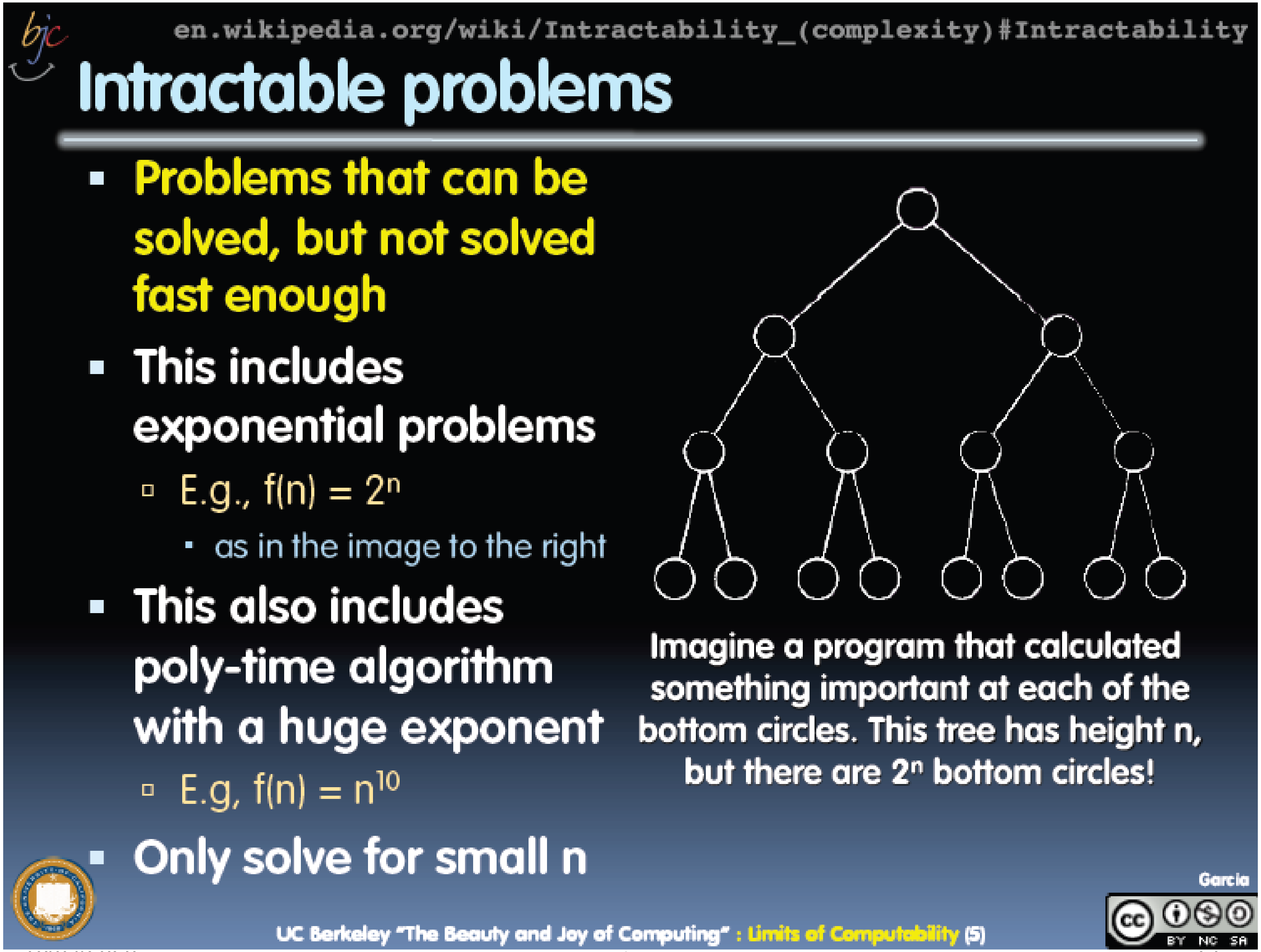
(c) Dan Garcia

- → 2 kategori terakhir tidak dibahas dalam kuliah ini

Dapat dikerjakan dengan solusi yang efisien dalam waktu yang wajar

- Kecepatan solusi “tumbuh” secara polinomial relatif terhadap ukuran persoalan (data)
- Contoh:
  - Mengurutkan kumpulan objek (*collection*)
  - Menemukan apakah dua angka dalam sebuah koleksi adalah sama
- Persoalan-persoalan tsb disebut sbg **“in P”** (polynomial)

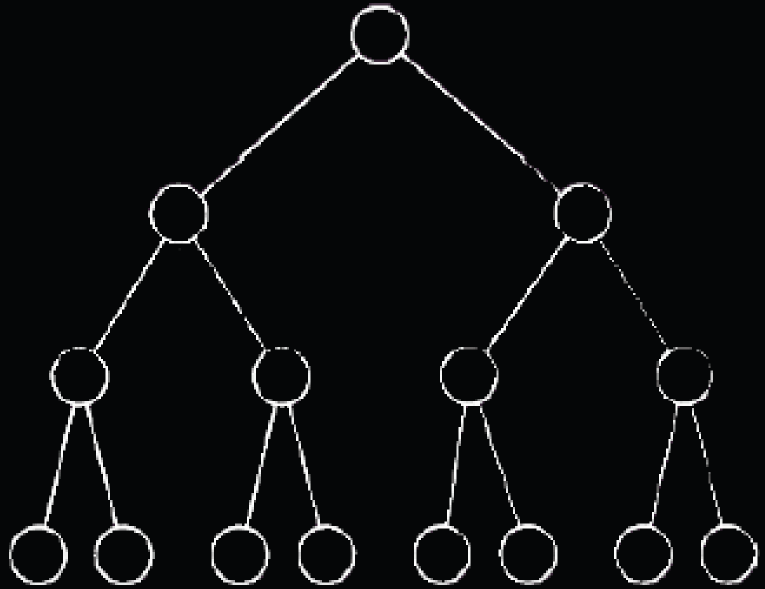
(c) Dan Garcia



en.wikipedia.org/wiki/Intractability_(complexity)#Intractability

Intractable problems

- Problems that can be solved, but not solved fast enough
- This includes exponential problems
  - E.g., $f(n) = 2^n$
    - as in the image to the right
- This also includes poly-time algorithm with a huge exponent
  - E.g, $f(n) = n^{10}$
- Only solve for small n



Imagine a program that calculated something important at each of the bottom circles. This tree has height n, but there are 2^n bottom circles!

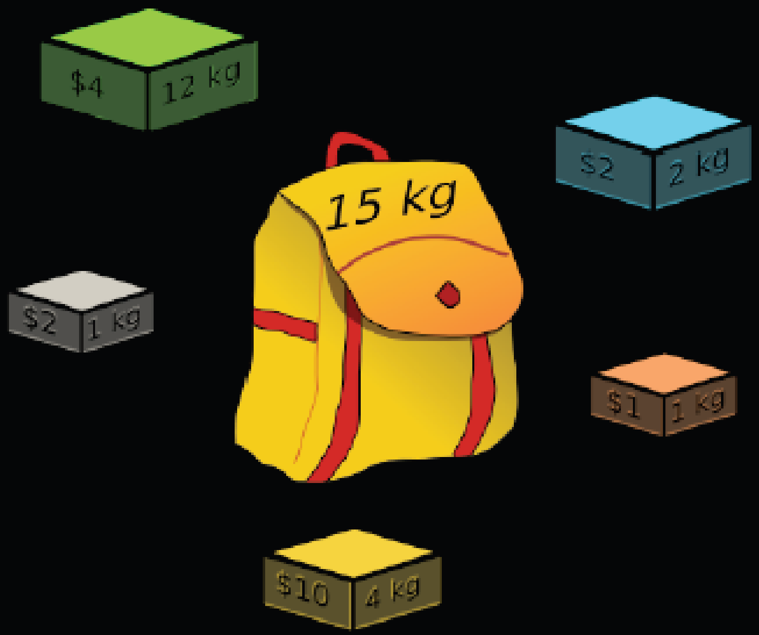
Garcia

UC Berkeley "The Beauty and Joy of Computing" : Limits of Computability (5)

Peer Instruction

What's the most you can put in your knapsack?

a) $10
b) $15
c) $33
d) $36
e) $40



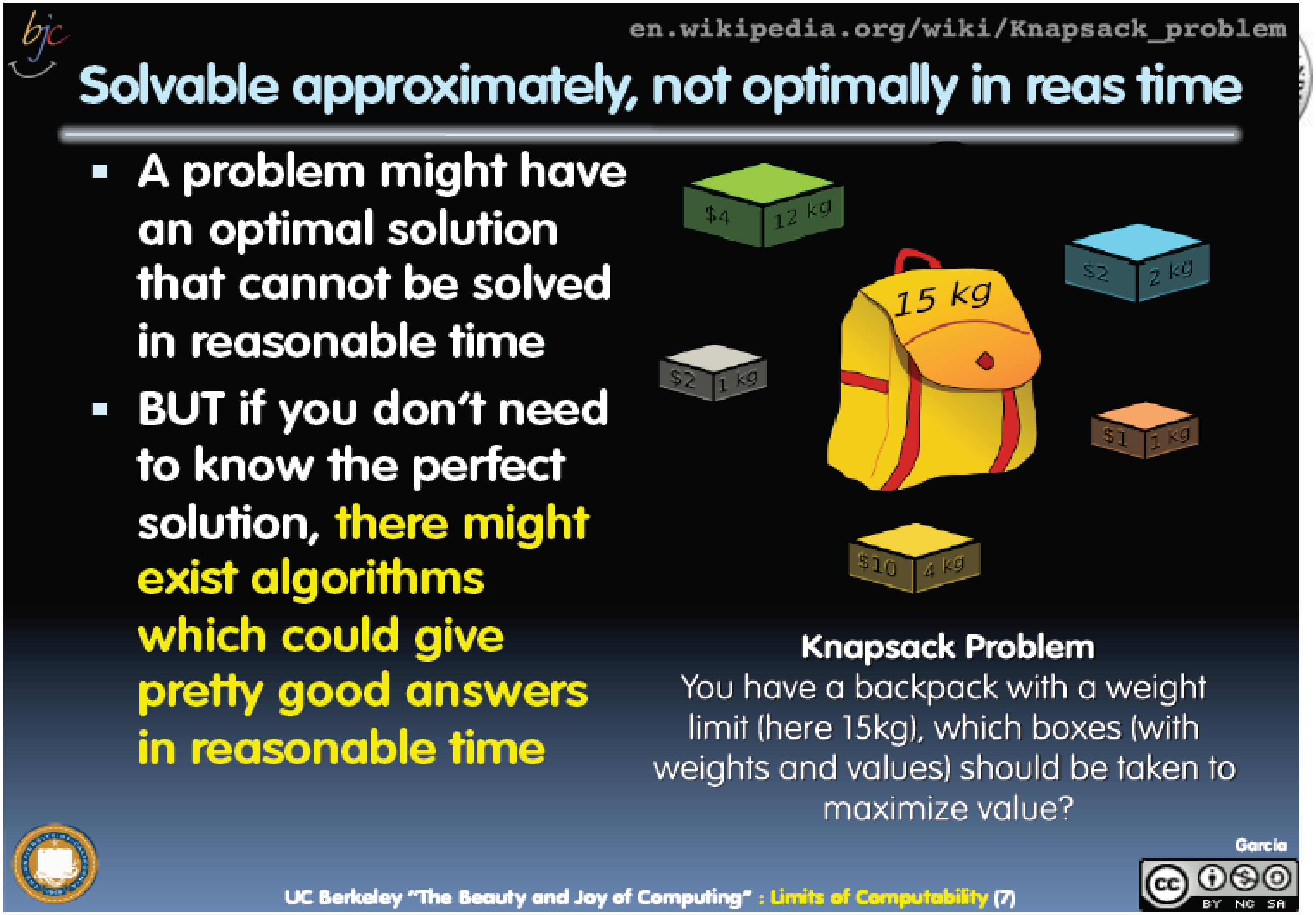
Knapsack Problem

You have a backpack with a weight limit (here **15kg**), which boxes (with weights and values) should be taken to maximize value?

(any # of each box is available)

Garcia

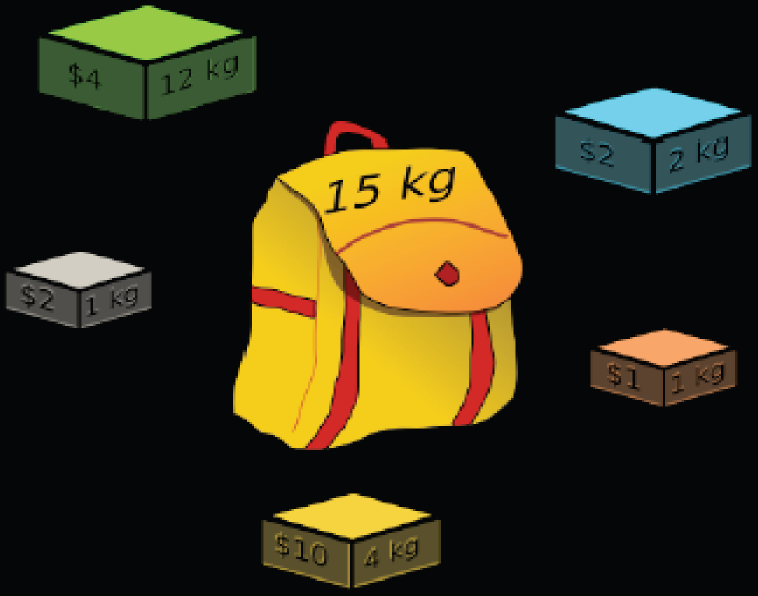
UC Berkeley "The Beauty and Joy of Computing" : Limits of Computability (6)



en.wikipedia.org/wiki/Knapsack_problem

Solvable approximately, not optimally in reas time

- A problem might have an optimal solution that cannot be solved in reasonable time
- BUT if you don't need to know the perfect solution, there might exist algorithms which could give pretty good answers in reasonable time



Knapsack Problem

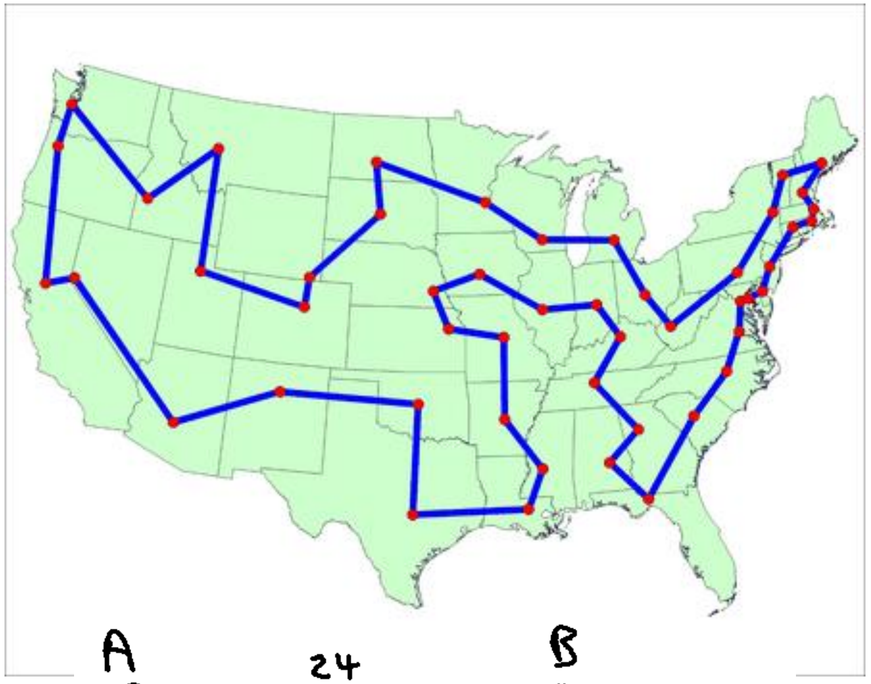
You have a backpack with a weight limit (here 15kg), which boxes (with weights and values) should be taken to maximize value?

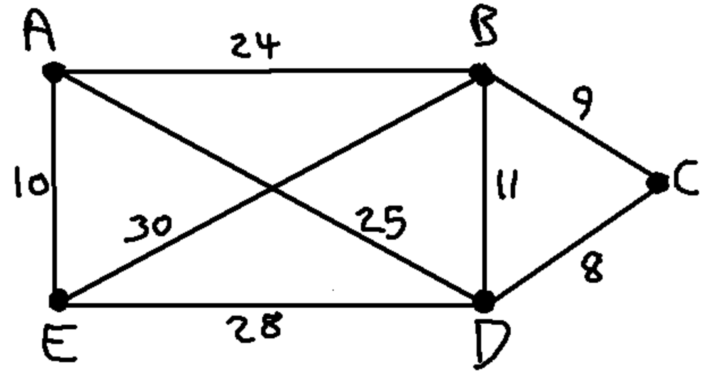
Garcia

UC Berkeley "The Beauty and Joy of Computing" : Limits of Computability (7)

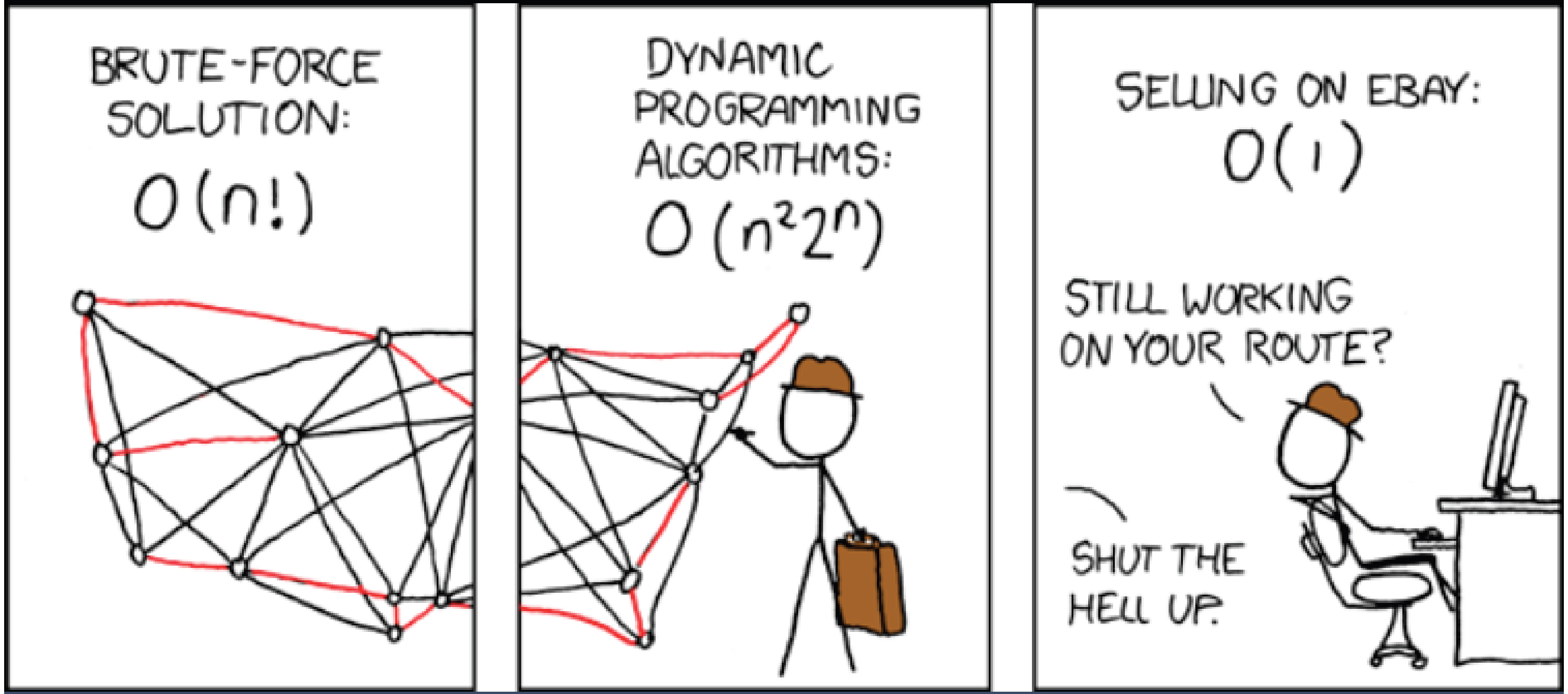
Travelling Salesman Problem

- Diberikan daftar kota dan jarak antar pasangan kota, tentukan rute terpendek untuk mengunjungi semua kota masing-masing tepat hanya satu kali dan selanjutnya kembali ke kota asal.





imgs.xkcd.com/comics/travelling_salesman_problem.png


BRUTE-FORCE SOLUTION: O(n!)
DYNAMIC PROGRAMMING ALGORITHMS: O(n²2ⁿ)
SELLING ON EBAY: O(1)
STILL WORKING ON YOUR ROUTE?
SHUT THE HELL UP.

UC Berkeley "The Beauty and Joy of Computing" : Limits of Computability (11)

Garcia

Best practices

- Jika diberikan sebuah problem yang sulit (hard problem), daripada mencoba sendiri menyelesaikan, lihat apakah sudah ada yang menyelesaikan **problem yang sejenis**
- Jika kita tidak perlu solusi yang tepat/exact, pertimbangkan menggunakan *approximation algorithm*
- Beberapa persoalan tidak dapat diselesaikan (dengan memprogram)

Lihat Video ini...

https://www.youtube.com/watch?v=EOuGmRXsb4g

Bagian 3:
Pemrograman di Lingkungan STEI & Perkembangan Disiplin Computing

Tujuan

- Memahami kuliah selanjutnya di STEI yang berkaitan dengan pemrograman
- Memahami taksonomi disiplin computing
- Memahami perkembangan disiplin keilmuan computing, teknologi dan aplikasinya yang mutakhir (RI 4.0)

Pemrograman di Lingkungan STEI

- Seluruh Prodi di STEI mengajarkan pemrograman, dengan tingkat kedalaman yang berbeda-beda:
  - EL dan EB:
    - EL2005 Pemecahan Masalah dengan C
    - EL2208 Praktikum Pemecahan Masalah dengan C
  - ET:
    - ET2107 Pemrograman
    - ET3107 Pemrograman Lanjut
  - EP:
    - EP3073 Analisis Numerik untuk Tenaga Listrik

Pemrograman di Lingkungan STEI (2)

- STI:
  - IF2111 Algoritma dan Struktur Data STI
  - IF2212 Pemrograman Berorientasi Objek STI
  - II3160 Teknologi Sistem Terintegrasi
  - II3260 Platform dan Pengembangan Aplikasi Mobile
  - dll
- IF:
  - IF2110 Algoritma & Struktur Data
  - IF2210 Pemrograman Berorientasi Objek
  - IF2211 Strategi Algoritma
  - IF3110 Pengembangan Aplikasi Berbasis Web
  - IF3210 Pengembangan Aplikasi pada Platform Khusus
  - Dll: TBFO, AOKomp, Probstat, OS, AI, ML, MBD, BD, RPL, PPL, SPT

Domain Computing

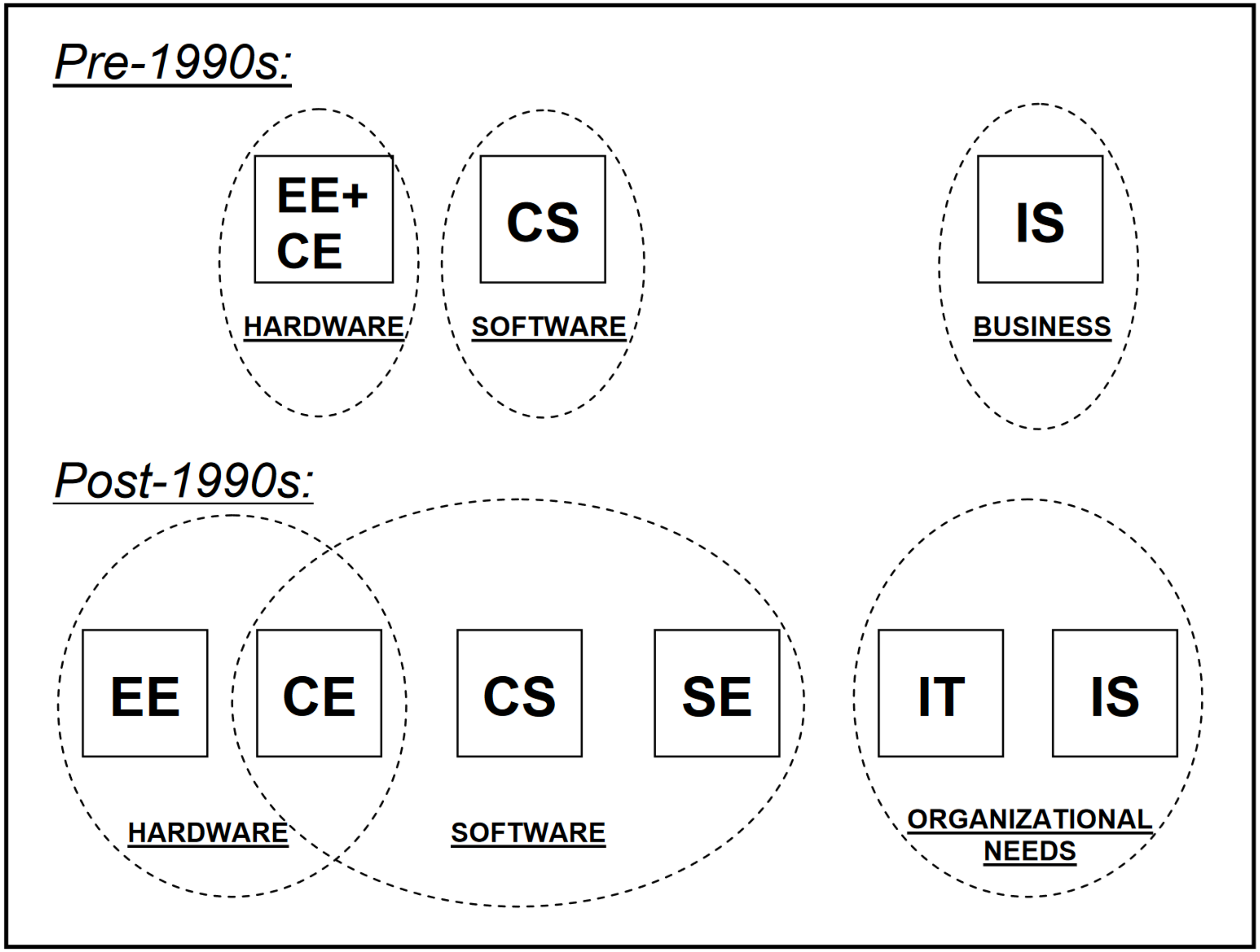


Figure 2.1. Harder Choices: How the Disciplines Might Appear to Prospective Students

- CE: the design and construction of computers and computer-based systems.
- the theories, principles, and practices of traditional electrical engineering and mathematics and applies them to the problems of designing computers and computer-based devices.
- CE study software development, focusing on software for digital devices and their interfaces with users and other devices. CE study may emphasize hardware more than software or there may be a balanced emphasis. CE has a strong engineering flavor.

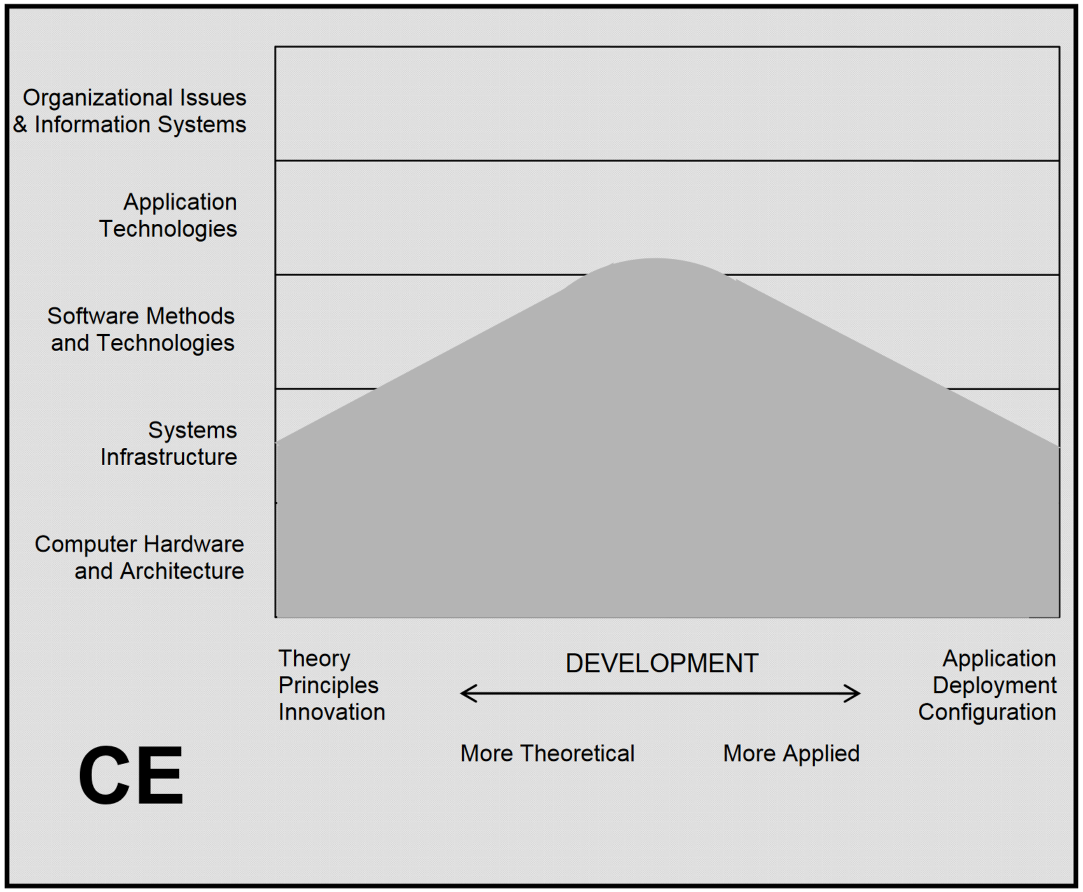
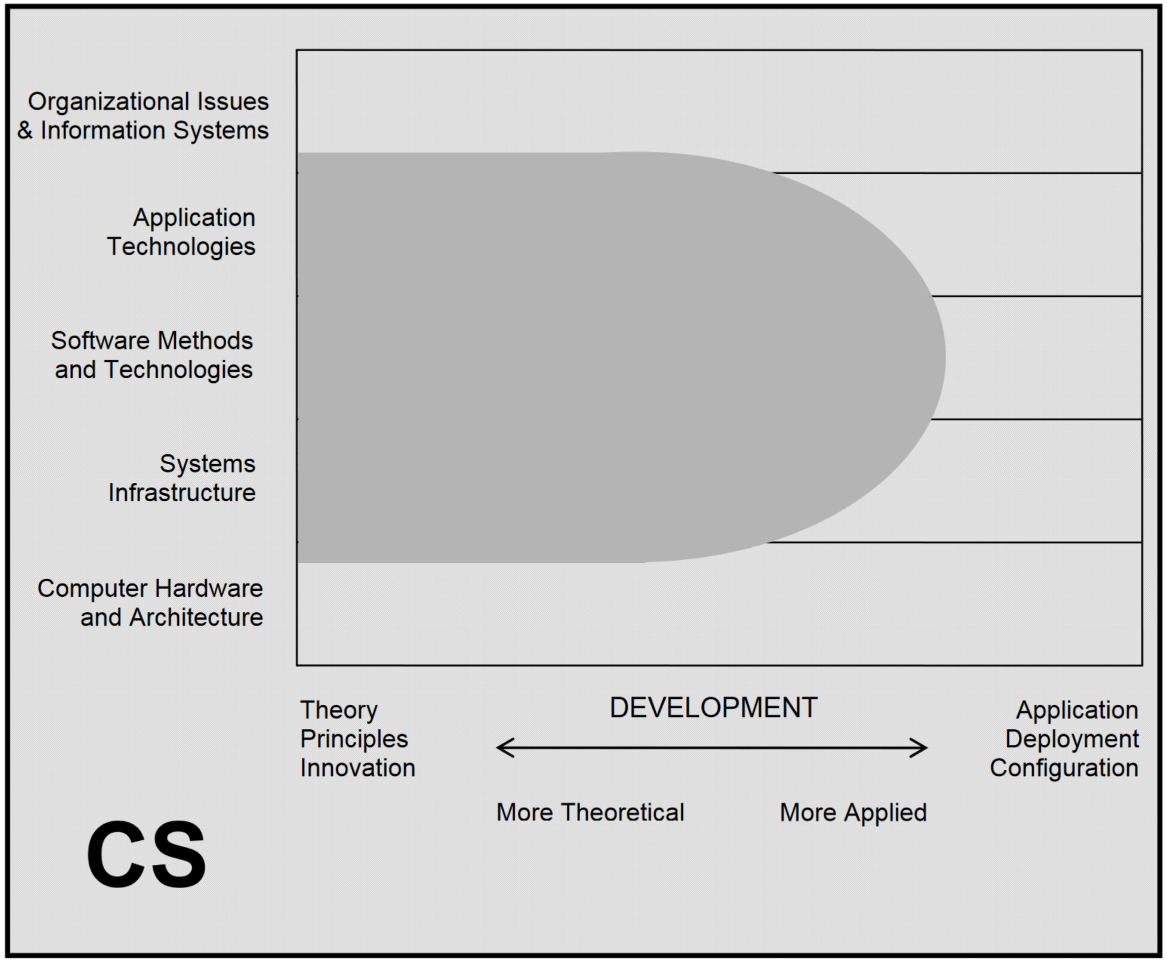

Organizational Issues & Information Systems
Application Technologies
Software Methods and Technologies
Systems Infrastructure
Computer Hardware and Architecture
Theory Principles Innovation
DEVELOPMENT
Application Deployment Configuration
More Theoretical
More Applied
CE

Figure 2.3. Computer Engineering

- The development of devices that have software and hardware, embedded systems/ devices such as cell phones, digital audio players, digital video recorders, alarm systems, x-ray machines, and laser surgical

[Computing Curricula 2005]

- CS spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in robotics, computer vision, intelligent systems, bioinformatics, and other exciting areas.
- Their theoretical background allows them to determine the best performance possible, and their study of algorithms helps **them to develop new approaches that provide better performance.**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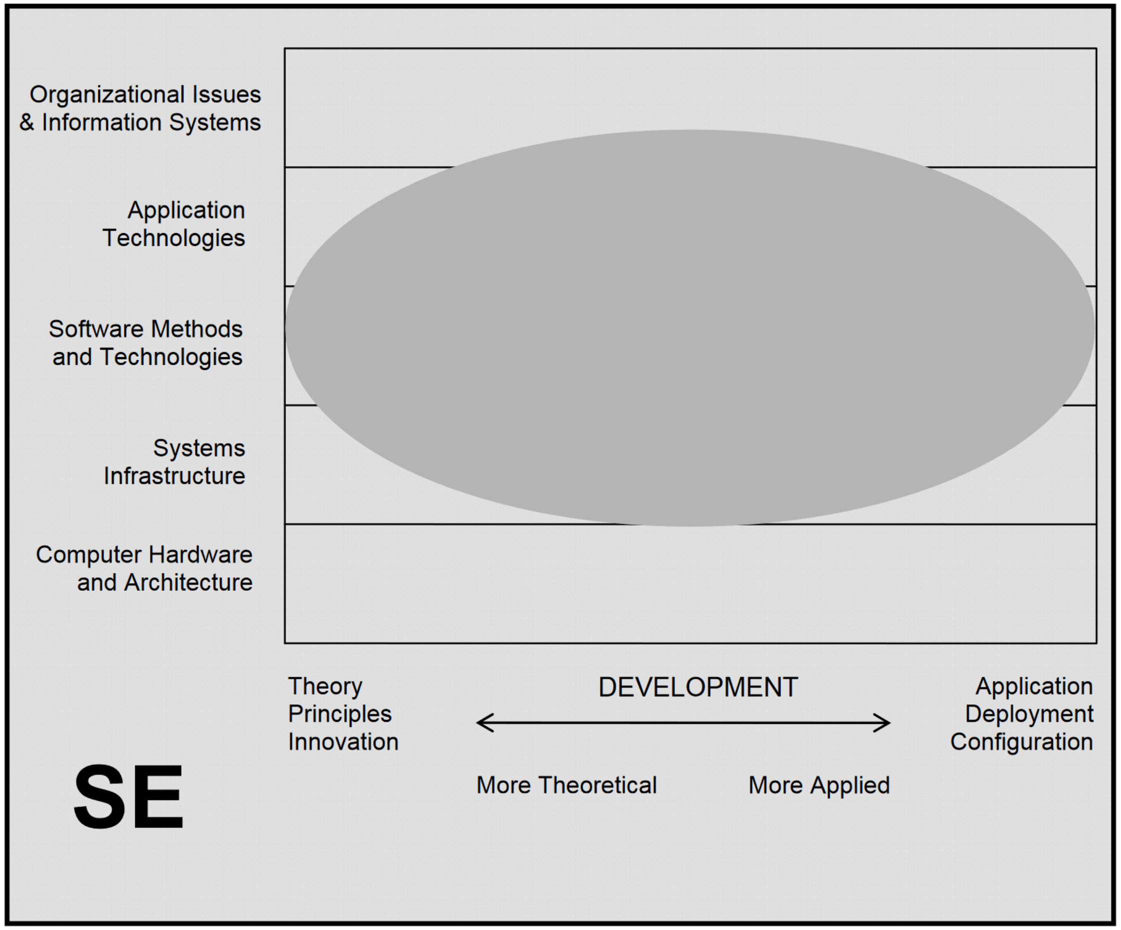
CS

Figure 2.4. Computer Science

- They design and develop all types of software from systems infrastructure (operating systems, communications programs, etc.) to application technologies (web browsers, databases, search engines, etc.)
- Computer scientists create these capabilities, but they do not manage the deployment of them. [Computing Curricula 2005]

- They design and develop all types of software from systems infrastructure (operating systems, communications programs, etc.) to application technologies (web browsers, databases, search engines, etc.)
- SE's main goal is to develop systematic models and reliable techniques for producing high-quality software on time and within budget, and these concerns extend all the way from theory and principles to daily practice.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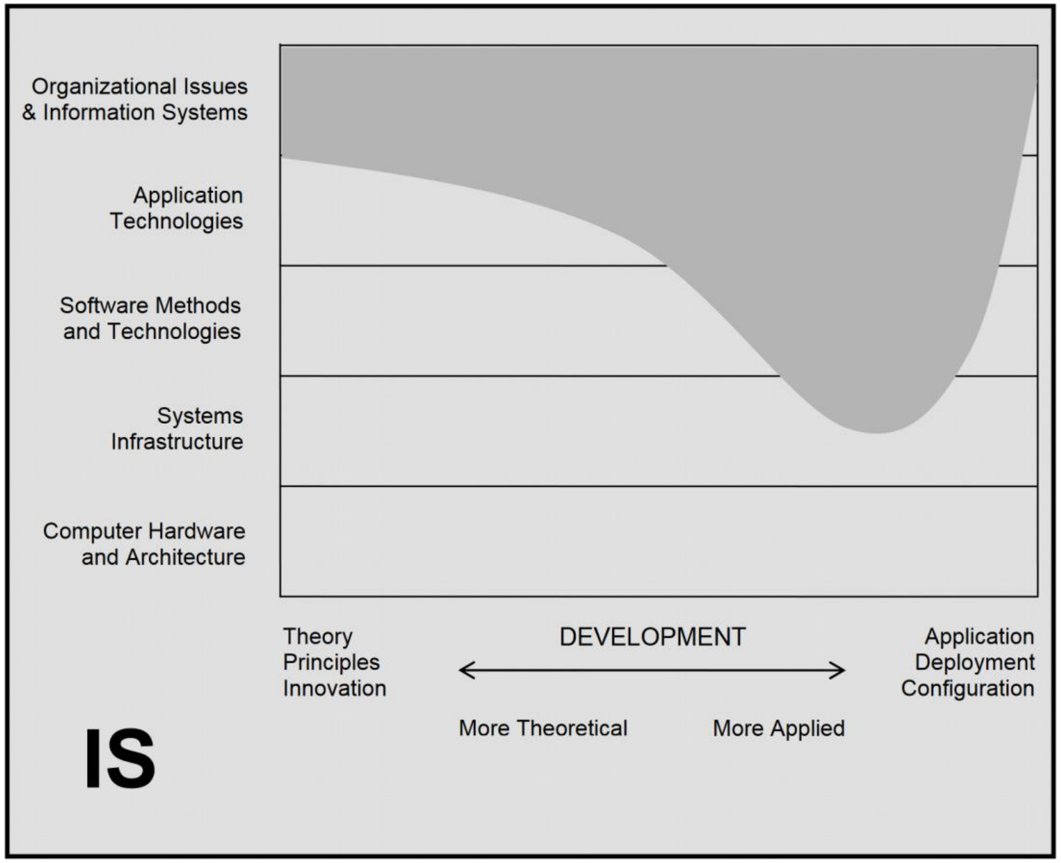
SE

Figure 2.7. Software Engineering

- Software engineering is different in character from other engineering disciplines due to both the intangible nature of software and the discontinuous nature of software operation. It seeks to integrate the principles of mathematics and computer science with the engineering practices developed for tangible, physical artifacts.

[Computing Curricula 2005]

- Information systems specialists focus on integrating information technology solutions and business processes to meet the information needs of businesses and other enterprises, enabling them to achieve their objectives in an effective, efficient way.
- They must understand both technical and organizational factors, and they must be able to help an organization determine how information and technology-enabled business processes can provide a competitive advantage.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More Theoretical
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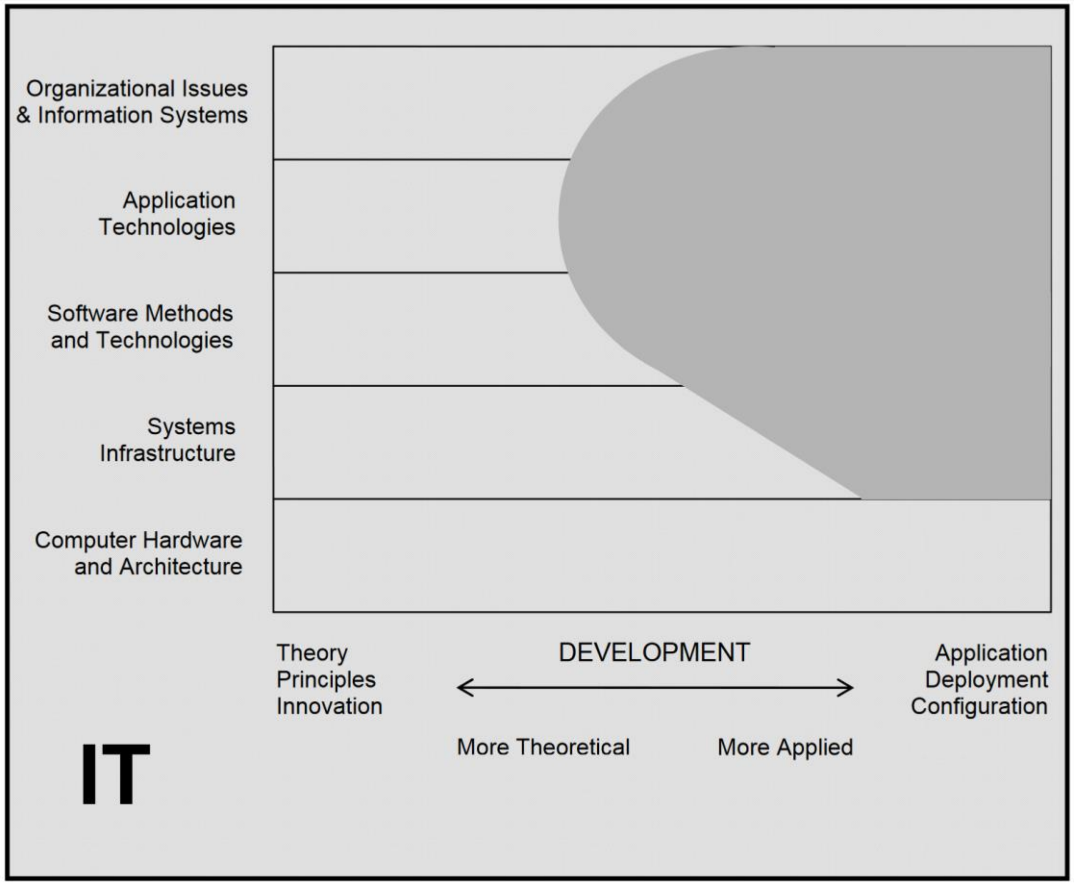
IS

Figure 2.5. Information Systems

- The information systems specialist plays a key role in determining the requirements for an organization's information systems and is active in their specification, design, and implementation.

[Computing Curricula 2005]

- IT specialists assume responsibility for selecting hardware and software products appropriate for an organization, integrating those products with organizational needs and infrastructure, and installing, customizing, and maintaining those applications for the organization's computer users.
- Examples of these responsibilities include the installation of networks; network administration and security; the design of web pages; the development of multimedia resources; the installation of communication components; the oversight of email systems; and the planning and management of the technology lifecycle by which an organization's technology is maintained, upgraded, and replaced.


Organizational Issues & Information Systems
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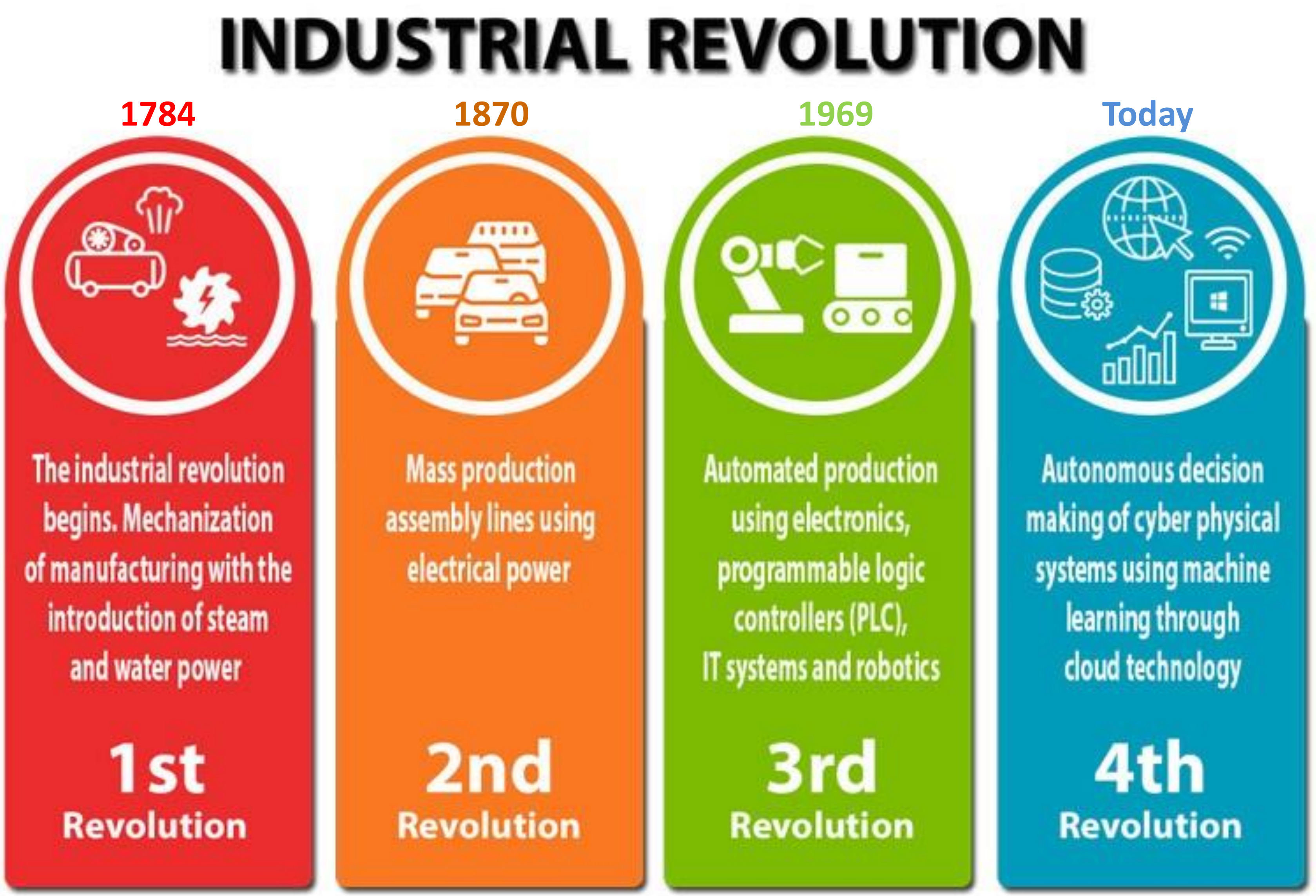
Theory Principles Innovation
DEVELOPMENT
Application Deployment Configuration
More Theoretical
More Applied
IT
Figure 2.6. Information Technology

[Computing Curricula 2005]



INDUSTRIAL REVOLUTION

1784

The industrial revolution begins. Mechanization of manufacturing with the introduction of steam and water power

1st Revolution

1870

Mass production assembly lines using electrical power

2nd Revolution

1969

Automated production using electronics, programmable logic controllers (PLC), IT systems and robotics

3rd Revolution

Today

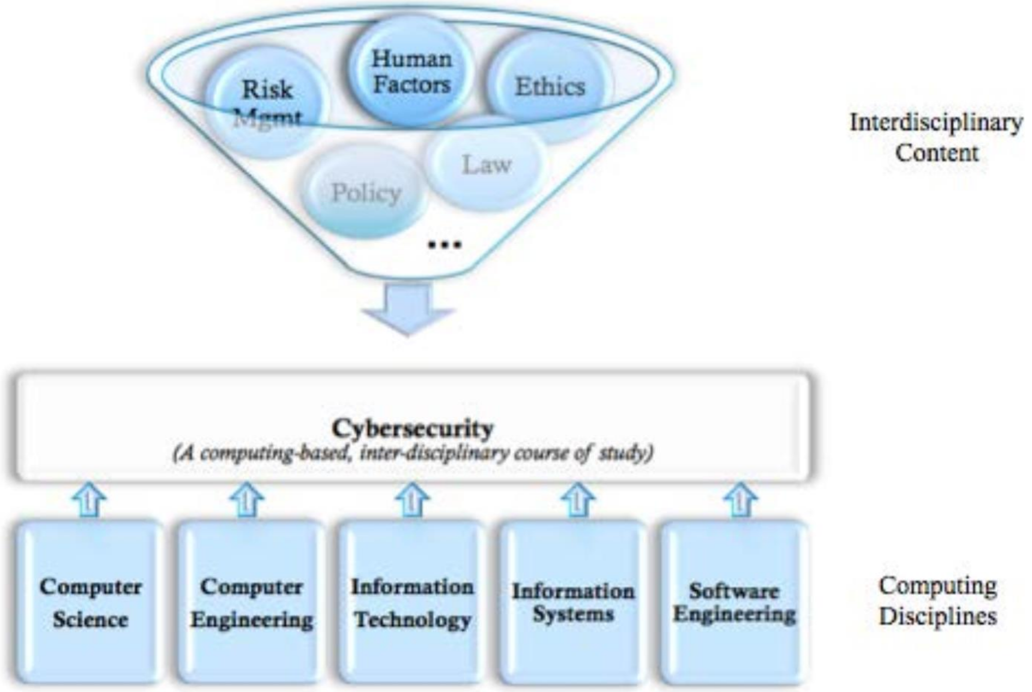
Autonomous decision making of cyber physical systems using machine learning through cloud technology

4th Revolution

https://www.studymalaysia.com/education/top-stories/the-fourth-industrial-revolution-ir-4.0-and-what-it-means-for-students-like-you

Cybersecurity

A computing-based discipline involving technology, people, information, and processes to enable assured operations in the context of adversaries. It involves the creation, operation, analysis, and testing of secure computer systems. It is an interdisciplinary course of study, including aspects of law, policy, human factors, ethics, and risk management. [The CSEC2017 JT]]

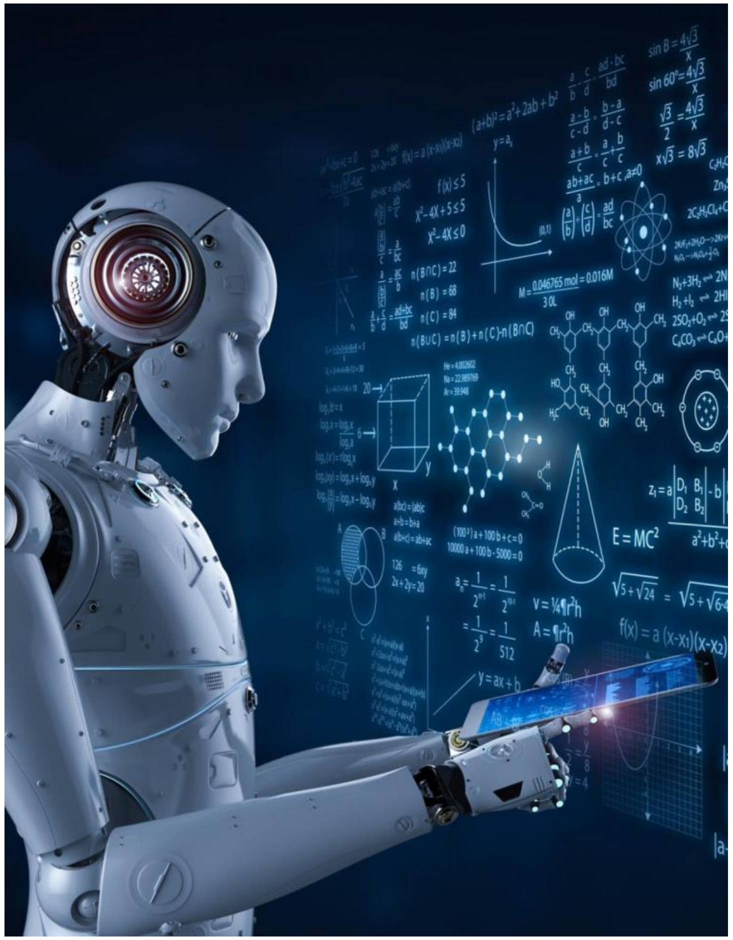


Cybersecurity is a computing-based discipline involving technology, people, information, and processes to enable assured operations in the context of adversaries. It draws from the foundational fields of information security and information assurance; and began with more narrowly focused field of computer security.

Artificial Intelligence

- “The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.” [The English Oxford Living Dictionary]

- Artificial Intelligence [Merriam-Webster]
  1. A branch of computer science dealing with the simulation of intelligent behavior in computers.
  2. The capability of a machine to imitate intelligent human behavior.



https://menafn.com/updates/pr/2020-04/13/S_fde8cedf-3image_story.jpg

Machine Learning

- a field of computer science that aims to teach computers how to learn and act without being explicitly programmed.

- an approach to data analysis that involves building and adapting models, which allow programs to "learn" through experience. Machine learning involves the construction of algorithms that adapt their models to improve their ability to make predictions.

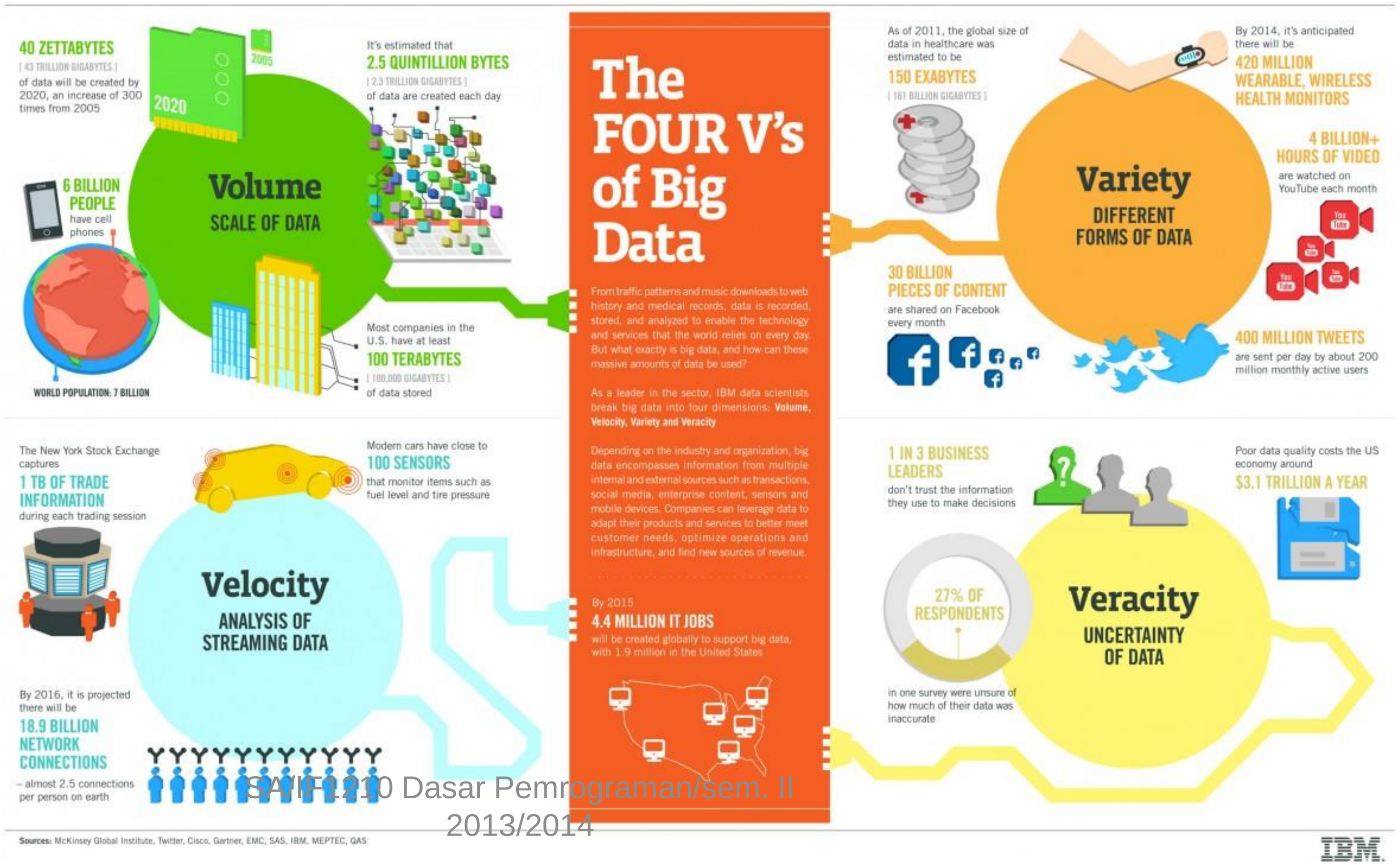
- Tom Mitchell: "a computer program is said to *learn* from experience *E* with respect to some task *T* and some performance measure *P*, if its performance on *T*, as measured by *P*, improves with experience *E*"
    - *a program uses machine learning if it improves at problem solving with experience*.

[https://deepai.org/machine-learning-glossary-and-terms/machine-learning]

Big Data

- Big Data consists of extensive datasets primarily in the characteristics of volume, variety, velocity, and/or variability that require a scalable architecture for efficient storage, manipulation, and analysis.

[NIST Big Data Interoperability Framework: Volume 1, Definitions]



The FOUR V's of Big Data

From traffic patterns and music downloads to web history and medical records, data is recorded, stored, and analyzed to enable the technology and services that the world relies on every day. But what exactly is big data, and how can these massive amounts of data be used?

As a leader in the sector, IBM data scientists break big data into four dimensions: **Volume, Velocity, Variety and Veracity**

Depending on the industry and organization, big data encompasses information from multiple internal and external sources such as transactions, social media, enterprise content, sensors and mobile devices. Companies can leverage data to adapt their products and services to better meet customer needs, optimize operations and infrastructure, and find new sources of revenue.

By 2015 **4.4 MILLION IT JOBS** will be created globally to support big data, with 1.9 million in the United States

Volume SCALE OF DATA

40 ZETTABYTES [43 TRILLION GIGABYTES] of data will be created by 2020, an increase of 300 times from 2005

It's estimated that **2.5 QUINTILLION BYTES** [2.3 TRILLION GIGABYTES] of data are created each day

6 BILLION PEOPLE have cell phones

WORLD POPULATION: 7 BILLION

Most companies in the U.S. have at least **100 TERABYTES** [100,000 GIGABYTES] of data stored

Variety DIFFERENT FORMS OF DATA

As of 2011, the global size of data in healthcare was estimated to be **150 EXABYTES** [161 BILLION GIGABYTES]

By 2014, it's anticipated there will be **420 MILLION WEARABLE, WIRELESS HEALTH MONITORS**

4 BILLION+ HOURS OF VIDEO are watched on YouTube each month

30 BILLION PIECES OF CONTENT are shared on Facebook every month

400 MILLION TWEETS are sent per day by about 200 million monthly active users

Velocity ANALYSIS OF STREAMING DATA

The New York Stock Exchange captures **1 TB OF TRADE INFORMATION** during each trading session

Modern cars have close to **100 SENSORS** that monitor items such as fuel level and tire pressure

By 2016, it is projected there will be **18.9 BILLION NETWORK CONNECTIONS** – almost 2.5 connections per person on earth

Veracity UNCERTAINTY OF DATA

1 IN 3 BUSINESS LEADERS don't trust the information they use to make decisions

27% OF RESPONDENTS in one survey were unsure of how much of their data was inaccurate

Poor data quality costs the US economy around **$3.1 TRILLION A YEAR**

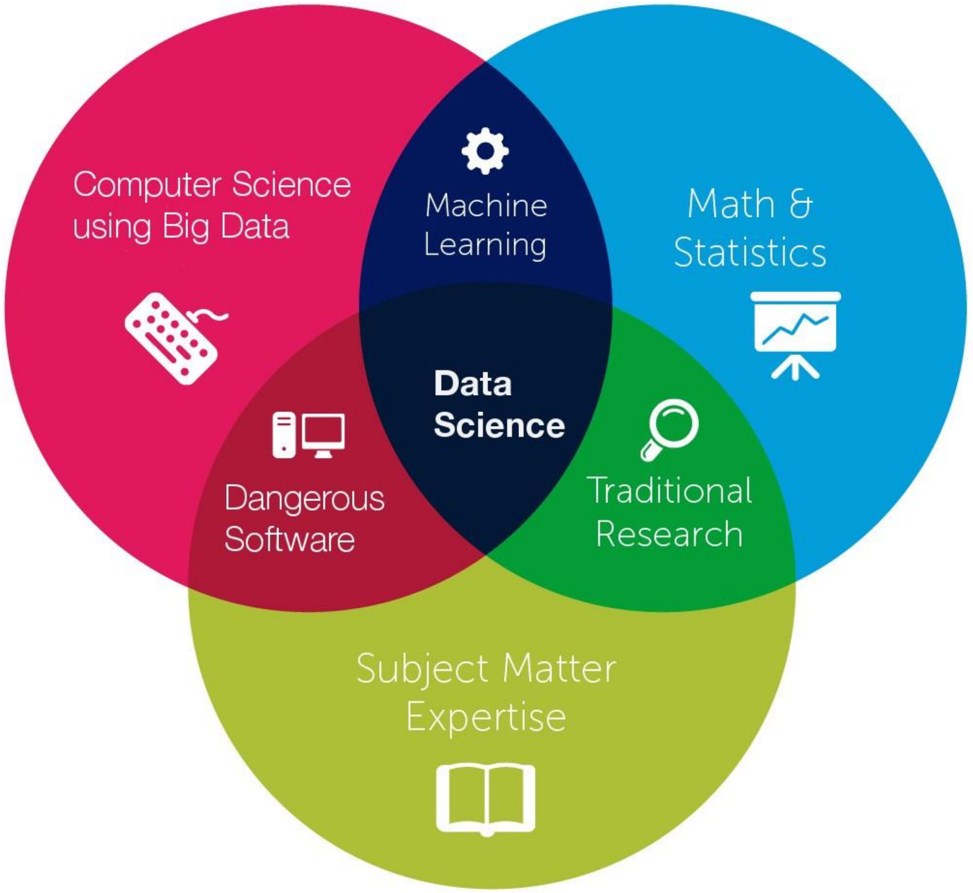
Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

Data Science

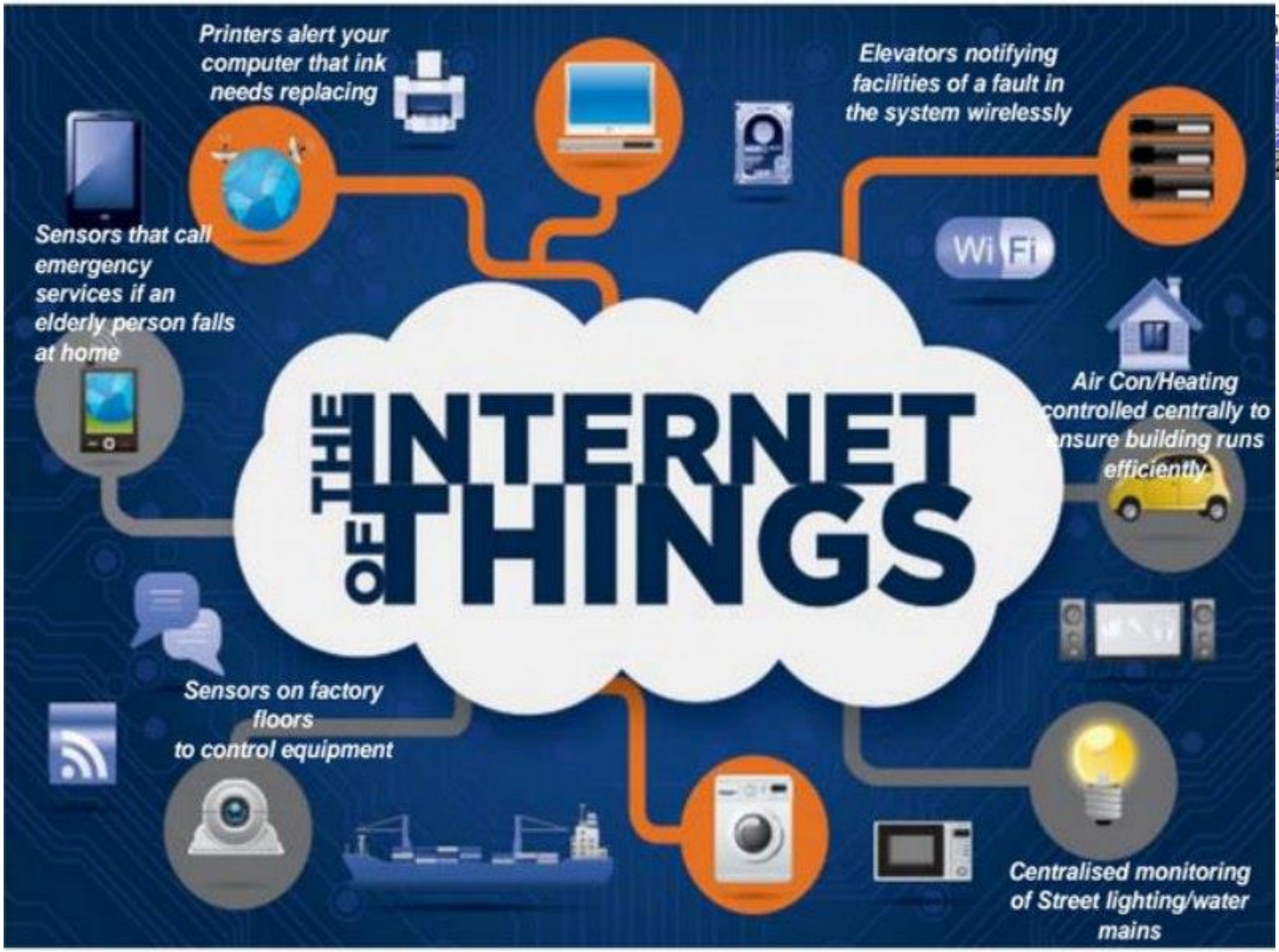
- Data science is the extraction of useful knowledge directly from data through a process of discovery, or of hypothesis formulation and hypothesis testing.

- A data scientistis a practitioner who has sufficient knowledge in the overlapping regimes of business needs, domain knowledge, analytical skills, and software and systems engineering to manage the end-to-end data processes in the analytics life cycle.

[NIST Big Data Interoperability Framework: Volume 1, Definitions]



https://medium.com/cutshort/how-to-become-a-data-scientist-a-detailed-step-by-step-guide-635b079937e2


Printers alert your computer that ink needs replacing
Elevators notifying facilities of a fault in the system wirelessly
Wi Fi
Sensors that call emergency services if an elderly person falls at home
THE INTERNET OF THINGS
Air Con/Heating controlled centrally to ensure building runs efficiently
Sensors on factory floors to control equipment
Centralised monitoring of Street lighting/water mains

http://shiftindonesia.com/internet-of-things-realita-baru-untuk-distributor-dan-produsen-manufaktur/

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https://www.youtube.com/watch?v=kpW9JcWxKq0

Have a great adventure...
To get the super power...