2110521
Software Architecture

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Duangdao Wichadakul

Neungwong Tuaycharoen

Agenda

- Course syllabus and grading policy
  - Focus on exercises and quizzes
  - No midterm exam
  - Term project
  - Online
- Definitions of software architecture
  - 5W2H (What, Why, When, Where, Who, How, How much)
  - Relevant topics

Syllabus

- See course syllabus
- Grading policy
- In-class activities
- Working in group for this semester
- A lot of exercises and quizzes
- Tools

Grading Policy 

- Quizzes 10%
- Assignments from tutorial 15%
- Term Project 50%
- Final Exam 25%
- No Midterm Exam

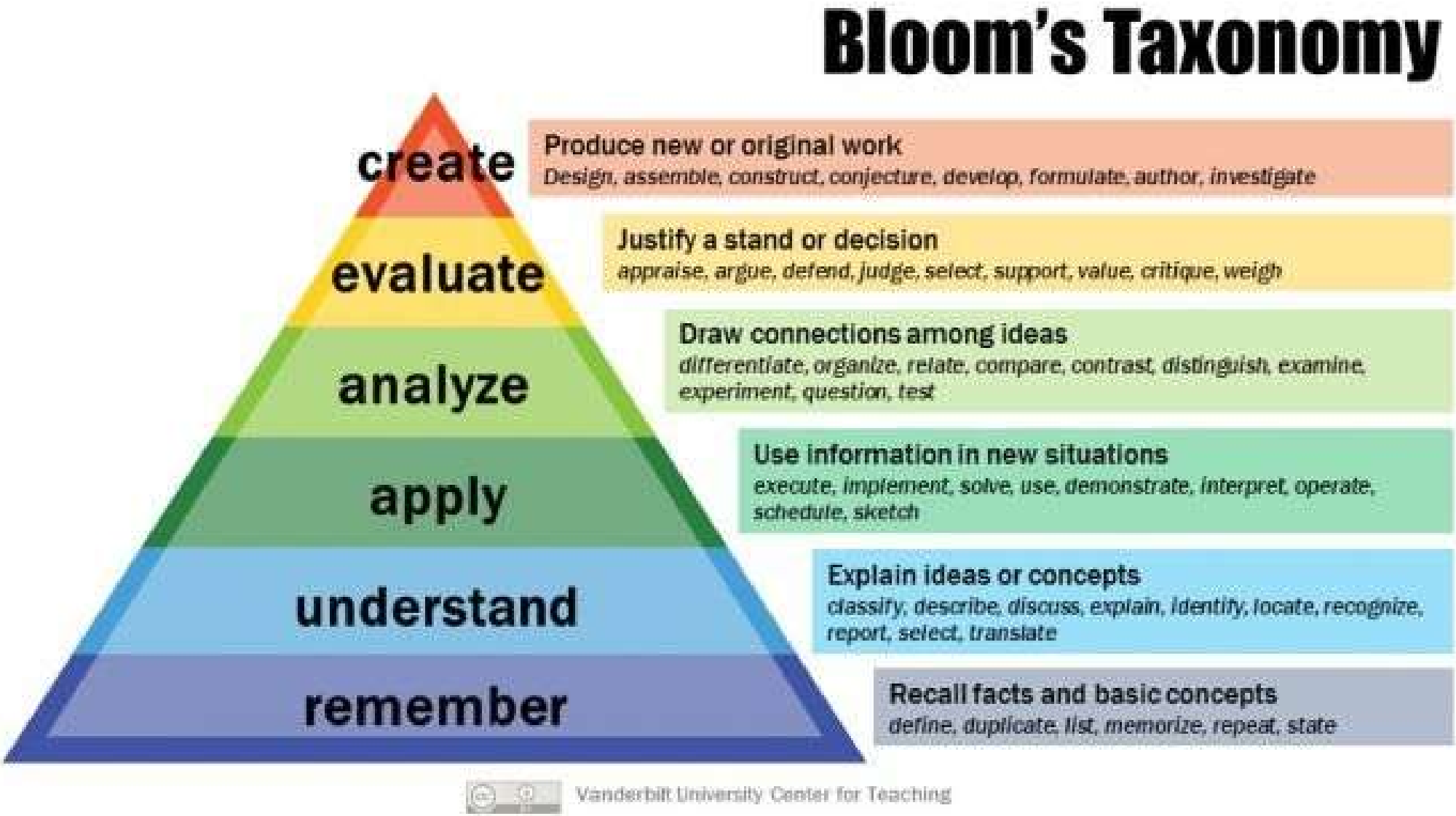
Resources

- Lecture slides & textbooks
- Hand on tutorials
- Software tools
- VDO recordings of lectures
- Notebook (recommended)

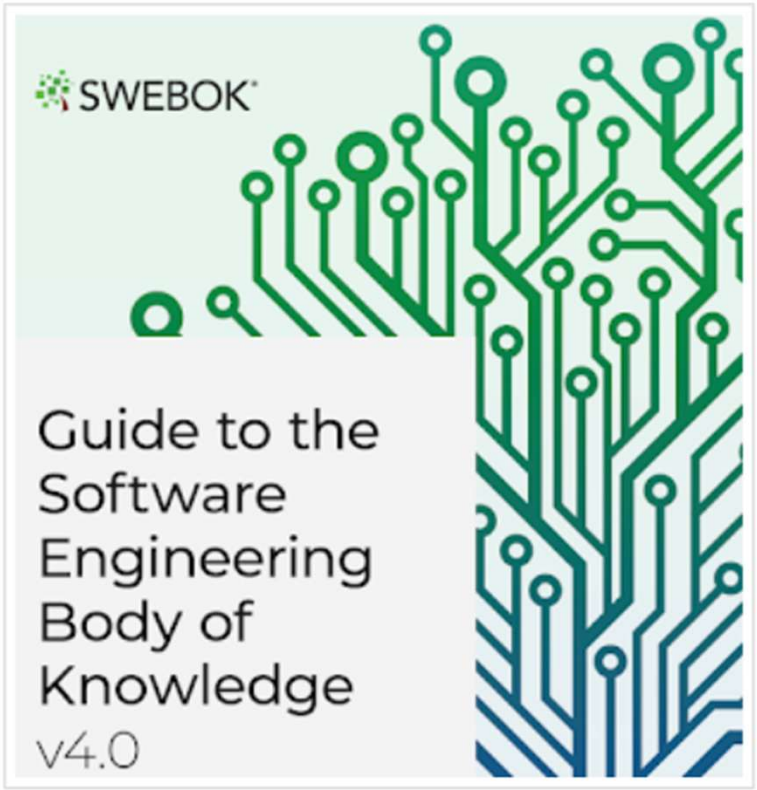
การนำเสนอเนื้อหา...ตื้นลึกต่างกัน

- Bloom's Taxonomy in 1956 by Benjamin Bloom and his colleagues
- เนื้อหาแต่ละส่วนในวิชานี้ มุ่งหวังสัมฤทธิ์ผลแตกต่างกัน ตามระดับของ Bloom
- จำง่าย ๆ คือ Aware, Understand, Implement ก็ได้

Taxonomy for Teaching, Learning, and Assessment in 2001



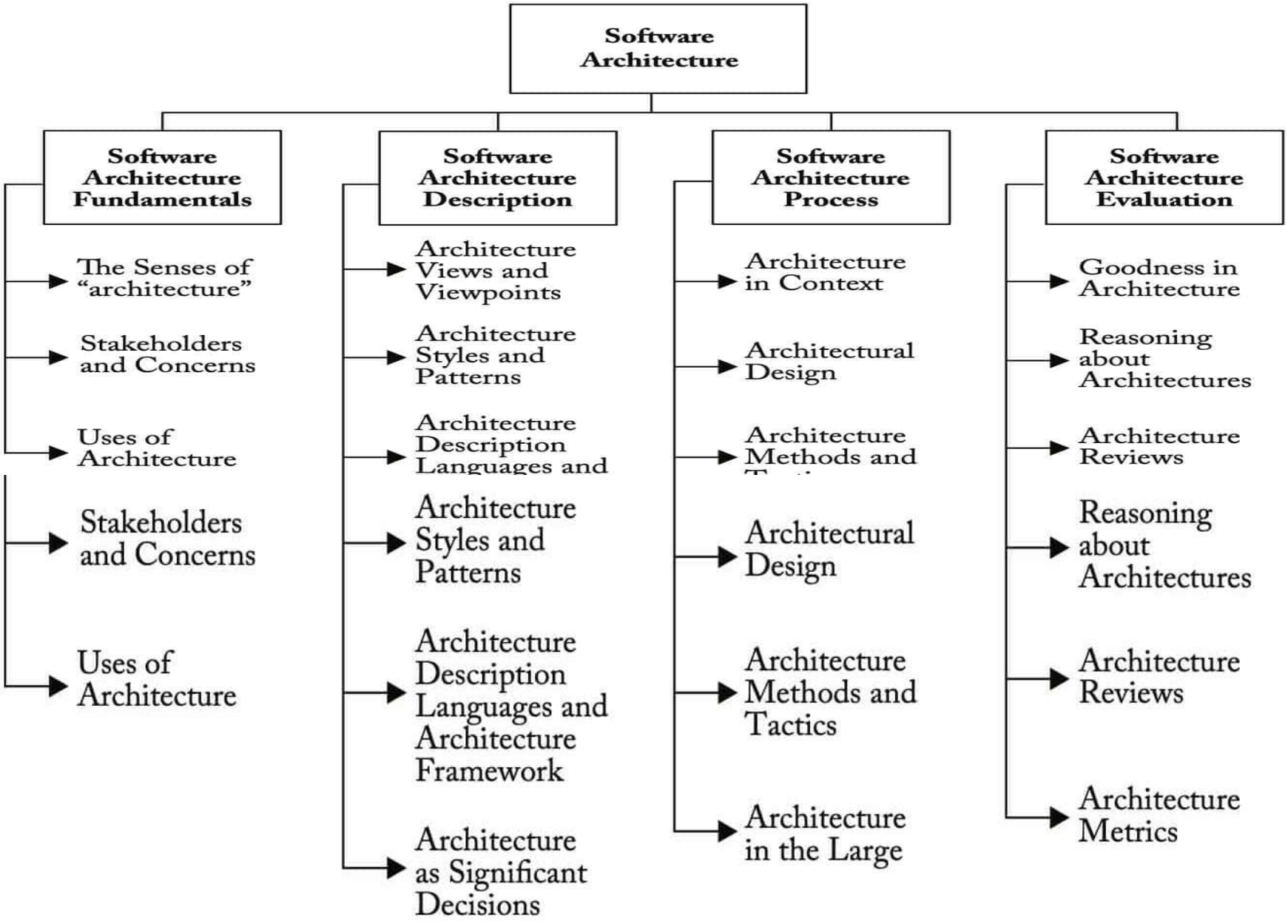
Guide to the SWEBOK v4.0 Has Been Released



The *Guide to the Software Engineering Body of Knowledge* (SWEBOK) v4.0 was released on October 15, 2024.

The Guide is a publication of the IEEE Computer Society (IEEE CS), and attempts to codify the collective knowledge, skills, techniques, methodologies, best practices, and experiences accumulated within the field of software engineering. Its goal is to bridge the divide between software engineering theory and practice. From the official announcement:

Knowledge Areas of SW ARCH



UML 2.5.1 Standards since Dec 2017

HOME SITE MAP LEGAL

OMG Standards Development Organization

GROUPS CERTIFICATIONS RESOURCES SPECIFICATIONS MEMBERSHIP

ABOUT THE UNIFIED MODELING LANGUAGE SPECIFICATION VERSION 2.5.1

2.5.1 • UML • SPECIFICATIONS

UML® Unified Modeling Language

A specification defining a graphical language for visualizing, specifying, constructing, and documenting the artifacts of distributed object systems.

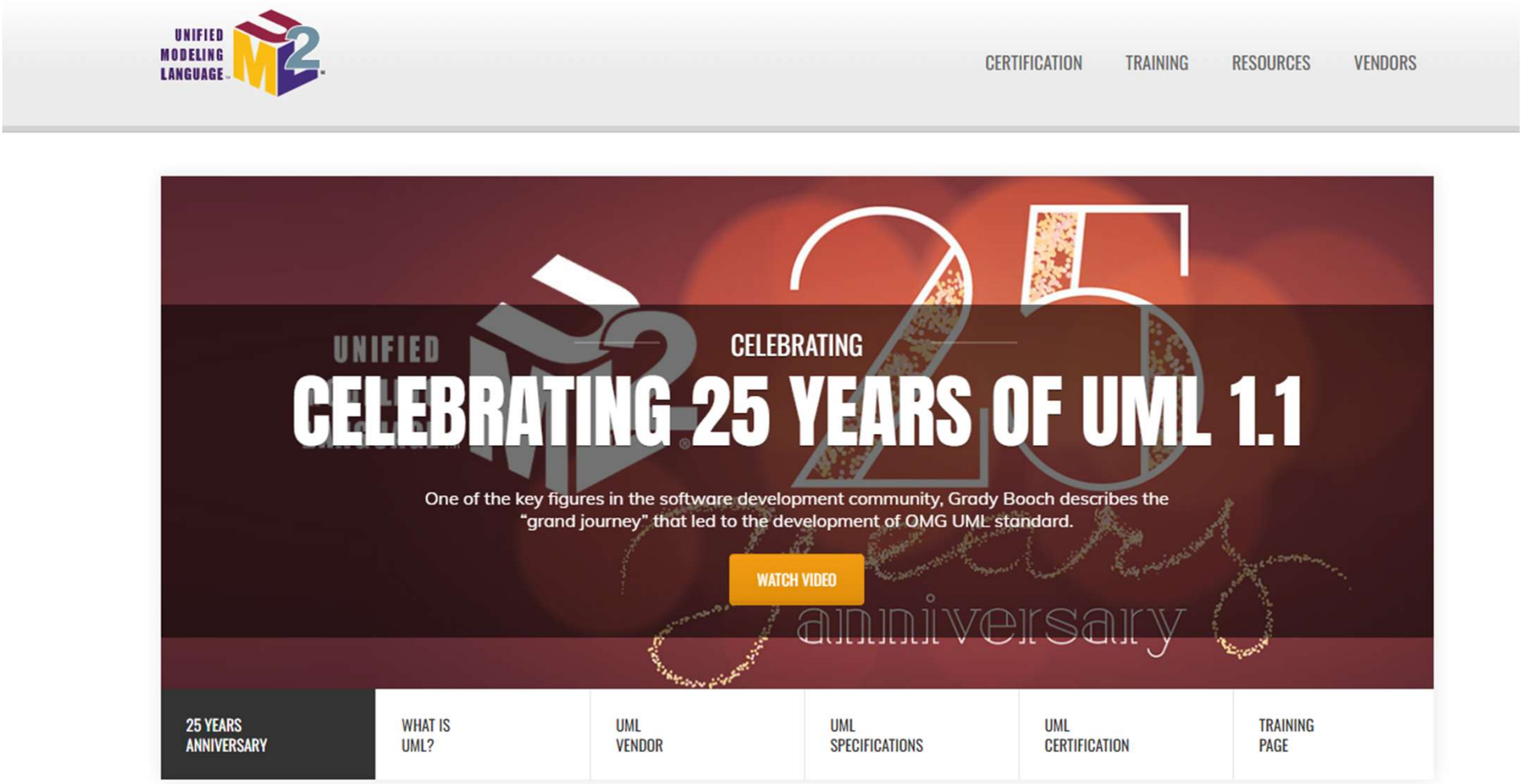
Specification

Title:	Unified Modeling Language
Acronym:	UML®
Version:	2.5.1
Document Status:	formal
Publication Date:	December 2017
Categories:	Modeling, Software Engineering, Platform
IPR Mode	RF-Limited

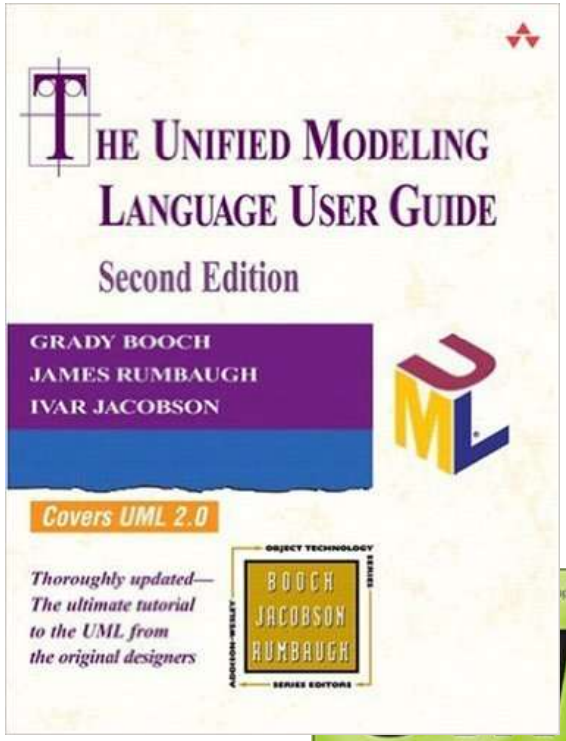
https://www.omg.org/spec/UML

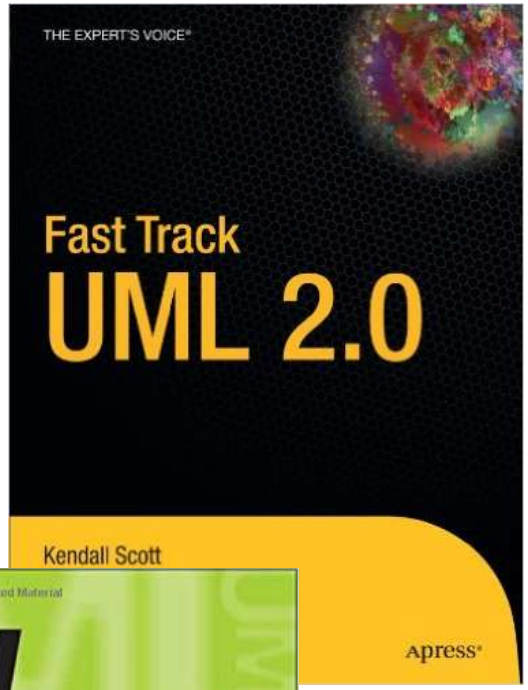
Version 2.5 is formally a minor revision to the UML 2.4.1 specification

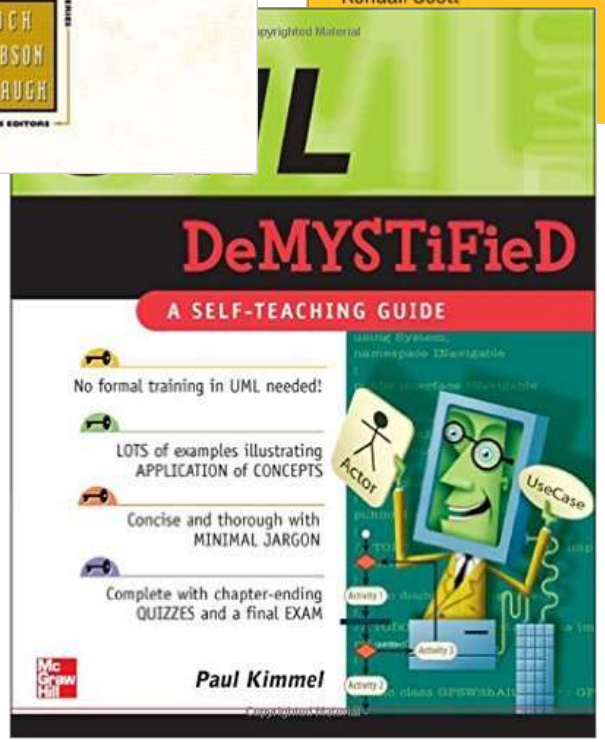
25 ปีแล้วนะ

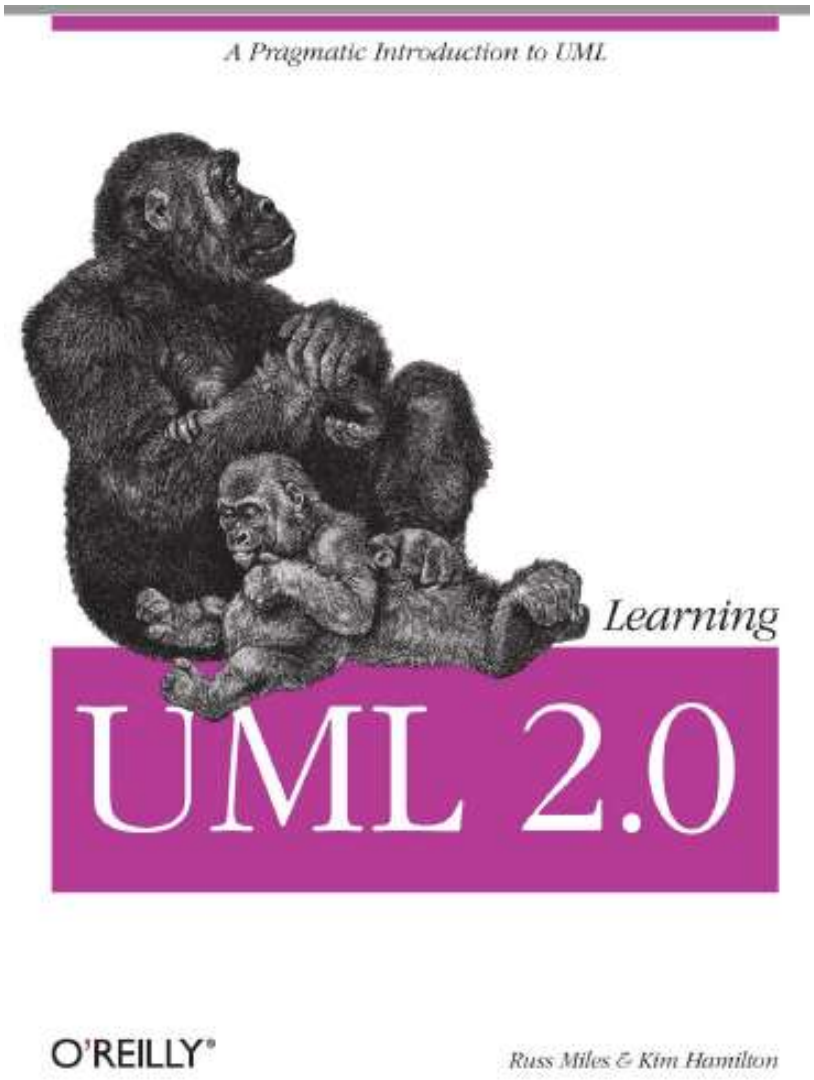

UNIFIED MODELING LANGUAGE
CERTIFICATION
TRAINING
RESOURCES
VENDORS
UNIFIED
CELEBRATING
CELEBRATING 25 YEARS OF UML 1.1
One of the key figures in the software development community, Grady Booch describes the "grand journey" that led to the development of OMG UML standard.
WATCH VIDEO
anniversary
25 YEARS ANNIVERSARY
WHAT IS UML?
UML VENDOR
UML SPECIFICATIONS
UML CERTIFICATION
TRAINING PAGE

UML 2.0


THE UNIFIED MODELING LANGUAGE USER GUIDE
Second Edition
GRADY BOOCH
JAMES RUMBAUGH
IVAR JACOBSON
Covers UML 2.0
Thoroughly updated—The ultimate tutorial to the UML from the original designers
BOOCH
JACOBSON
RUMBAUGH

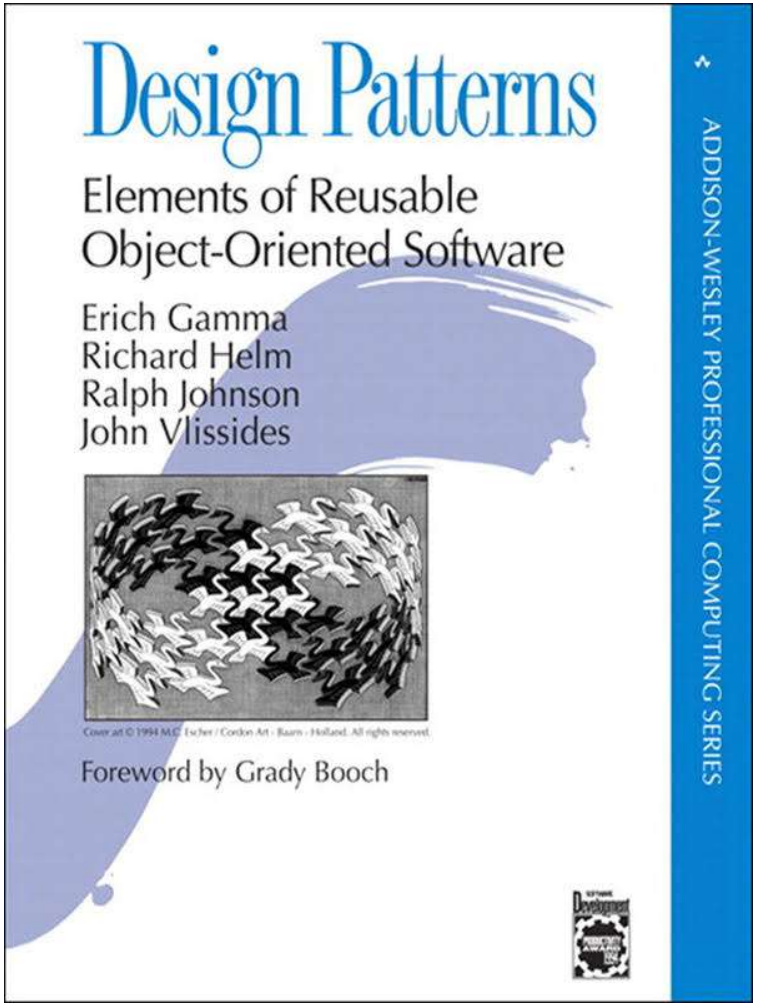

THE EXPERT'S VOICE®
Fast Track
UML 2.0
Kendall Scott
Apress®


DeMYSTiFieD
A SELF-TEACHING GUIDE
No formal training in UML needed!
LOTS of examples illustrating APPLICATION of CONCEPTS
Concise and thorough with MINIMAL JARGON
Complete with chapter-ending QUIZZES and a final EXAM
Paul Kimmel
Actor
UseCase

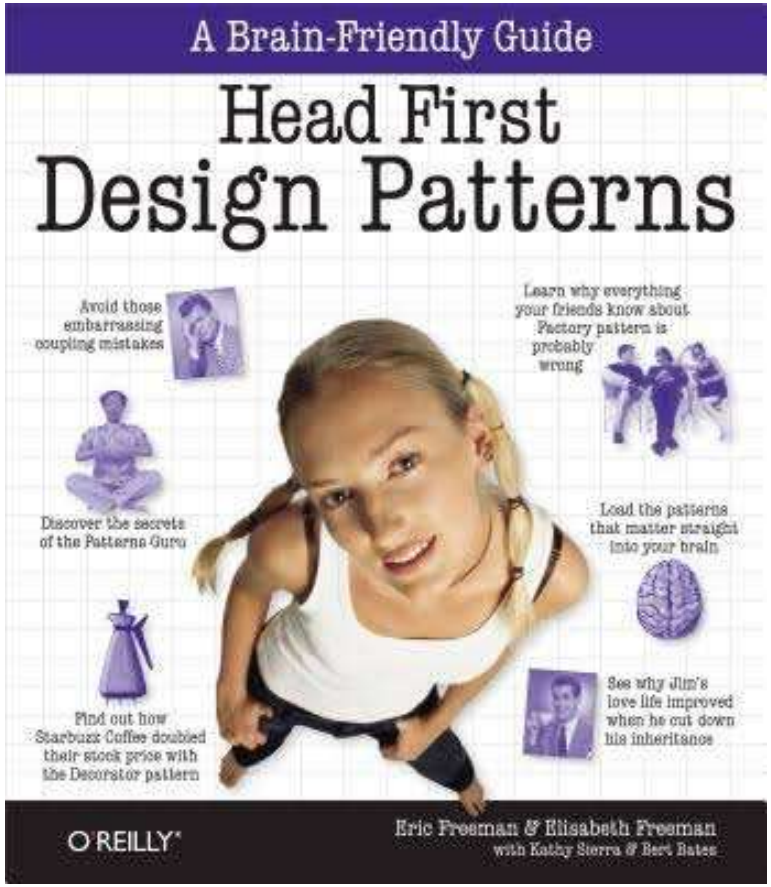

A Pragmatic Introduction to UML
Learning
UML 2.0
O'REILLY®
Russ Miles & Kim Hamilton

Design Patterns (optional)

เทอมนี้ ไม่มี



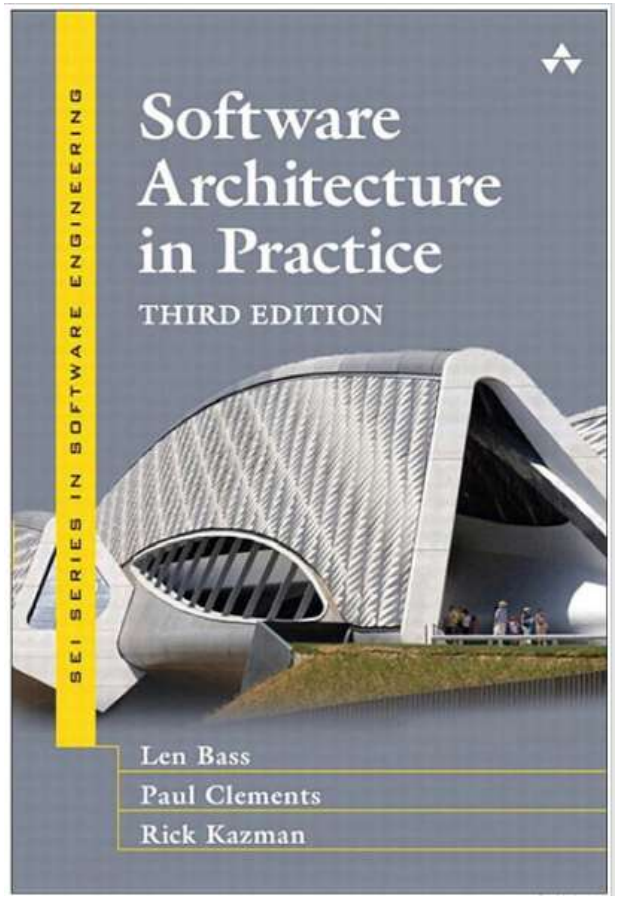
GoF Design Patterns

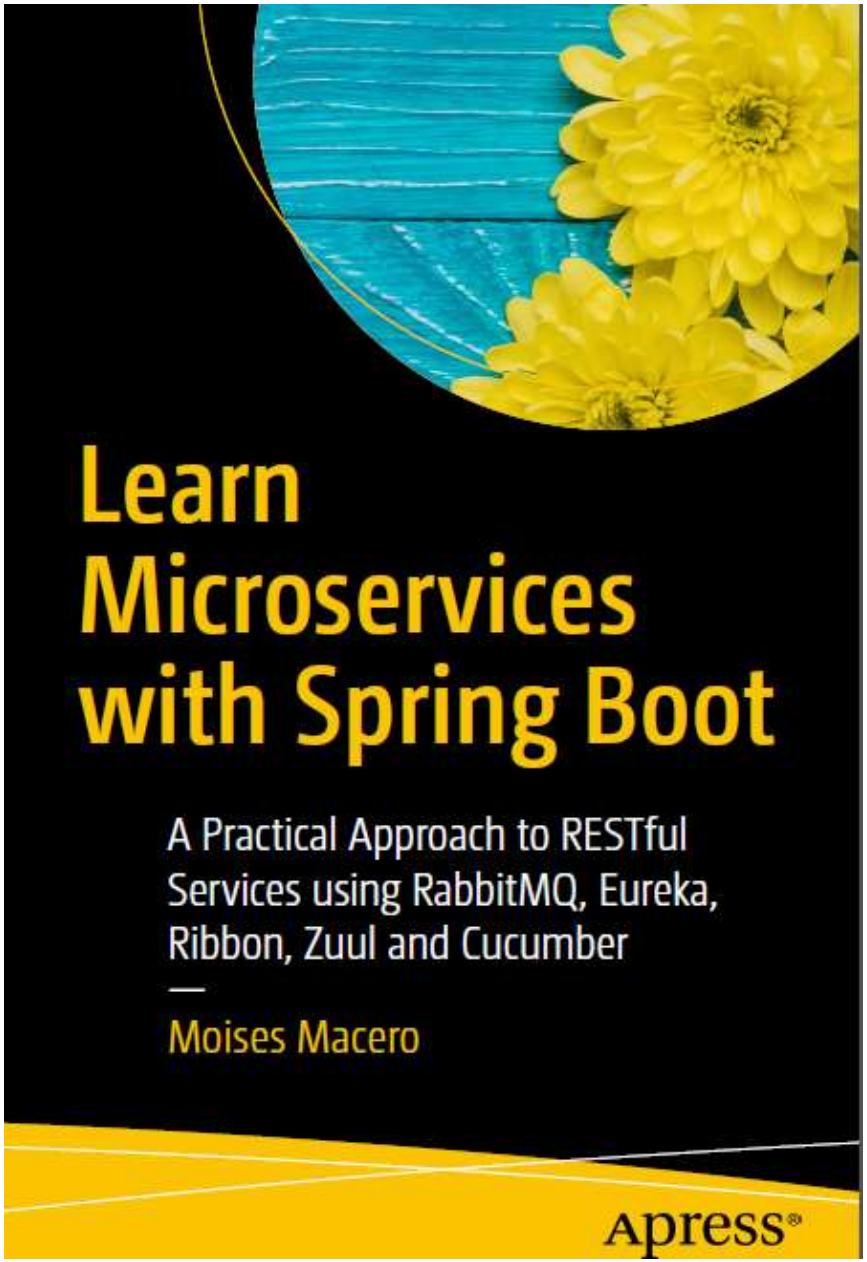


Design Patterns Made Simple

รวบรวมอยู่ใน

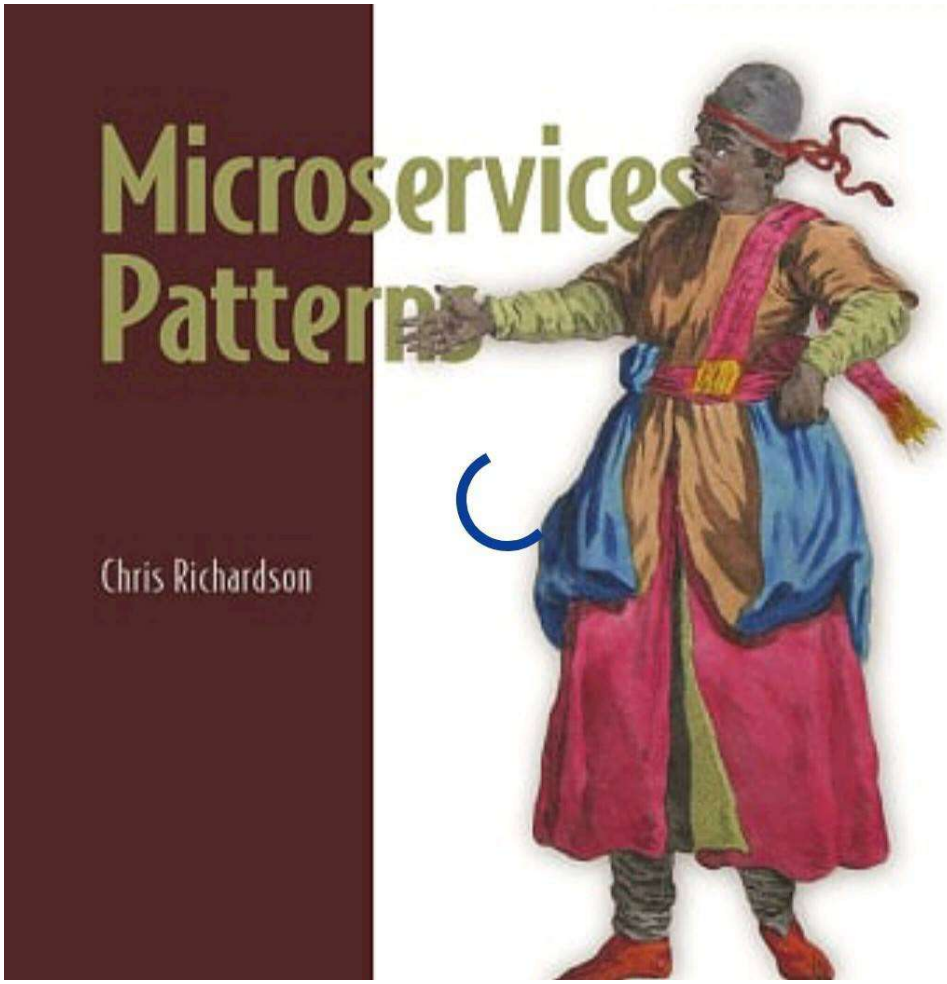
slide





เน้น เน้น

Microservices



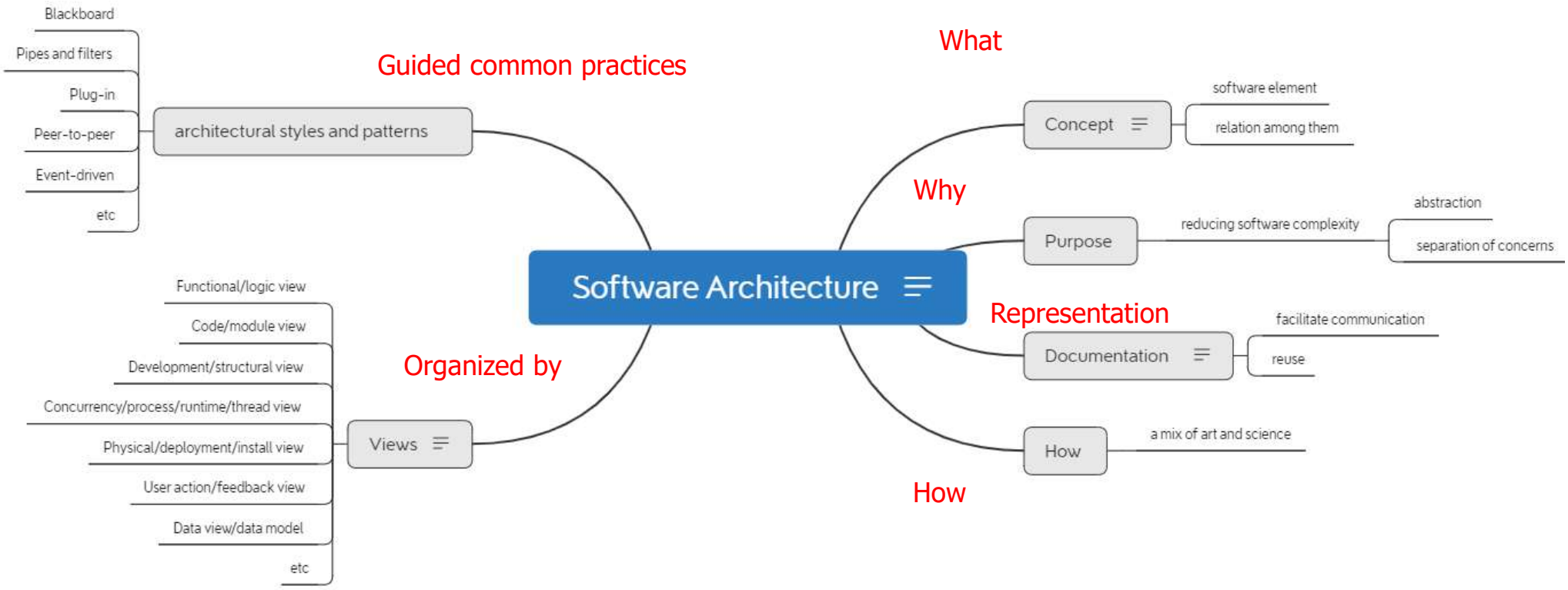
เข้าสู่เนื้อหาของวิชากันเลย

พยายามเดินเรื่องโดยใช้ 5W2H

What, Where, When, Who, Why, How, How much

Sw Arch Mindmap

เราสร้างแผนภาพ เพื่อความเข้าใจให้ง่ายขึ้น



Analogy

เปรียบเทียบ Software architecture กับสิ่งที่ใกล้ตัว

สร้างซอฟต์แวร์ขนาดใหญ่ เปรียบได้กับ สร้างตึกสูง

สร้างอาคาร 2 ชั้น แต่ละชั้นสูงไม่เกิน 4 เมตร ต่างกับสร้างอาคารสูง 100 ชั้น อย่างไร

วิศวกรเซ็นแบบ?

ความลึกเสาเข็ม ฐานราก

แล้วถ้าเป็น ซอฟต์แวร์??

SW Arch ถูกใช้เมื่อไร

Software Architecture
as
an Architectural Design

WHEN

Where Architecture Fits

- Requirements
  - What the system should do
  - What properties it should have
- Architecture
  - High-level design, how properties are achieved
- Detailed design
  - Lower-level design, how system functions
- Code
  - How the system actually works

เราส่งผ่าน input/output ของกิจกรรมต่าง ๆ ด้วย Model

Architectural Design (High level)

- Level of Abstraction
  - Top-down (High-to-Low level of abstraction) approach
- Architectural Design
  - Subsystem Design
- Complexity of the Design
  - Hiding and Omitting to Reduce the Complexity

- Detailed Design อาจจะมีรายละเอียดมากเกินไป
  - Object Design

Model คืออะไร มาเกี่ยวข้องอย่างไร

Model คือตัวแทนสิ่งที่เรากำลังสนใจ
ที่เราใช้เพื่อนำเสนอหรือสื่อสารกัน
(เพราะจัดหาของจริงมาไม่สะดวก)

Model หน้าตาเป็นอย่างไร

ถ้าเราสนใจสาวน้อยเทนนิส

→ Model ?

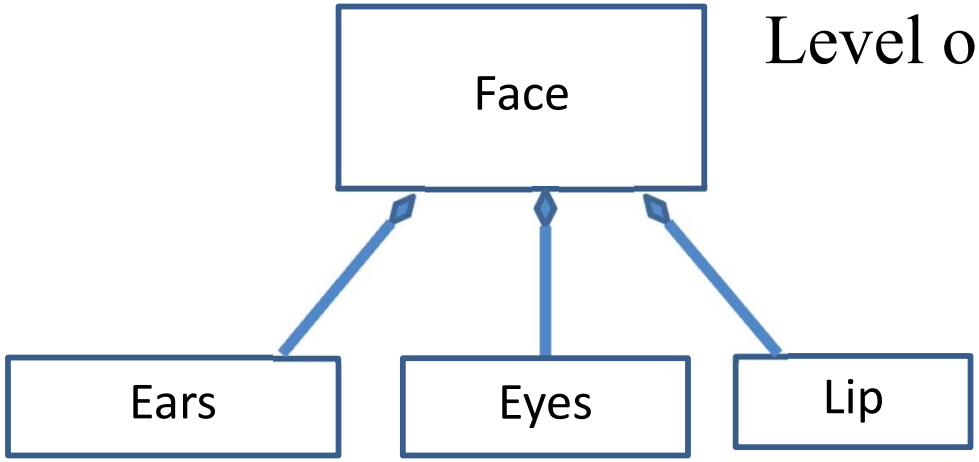
เช่น Structural model ของสาวน้อย
แล้ว Behavioral model เป็นอย่างไร?

Q: Level of Abstraction: High or Low?

ถ้าเราสนใจระบบซอฟต์แวร์

→ Model ?

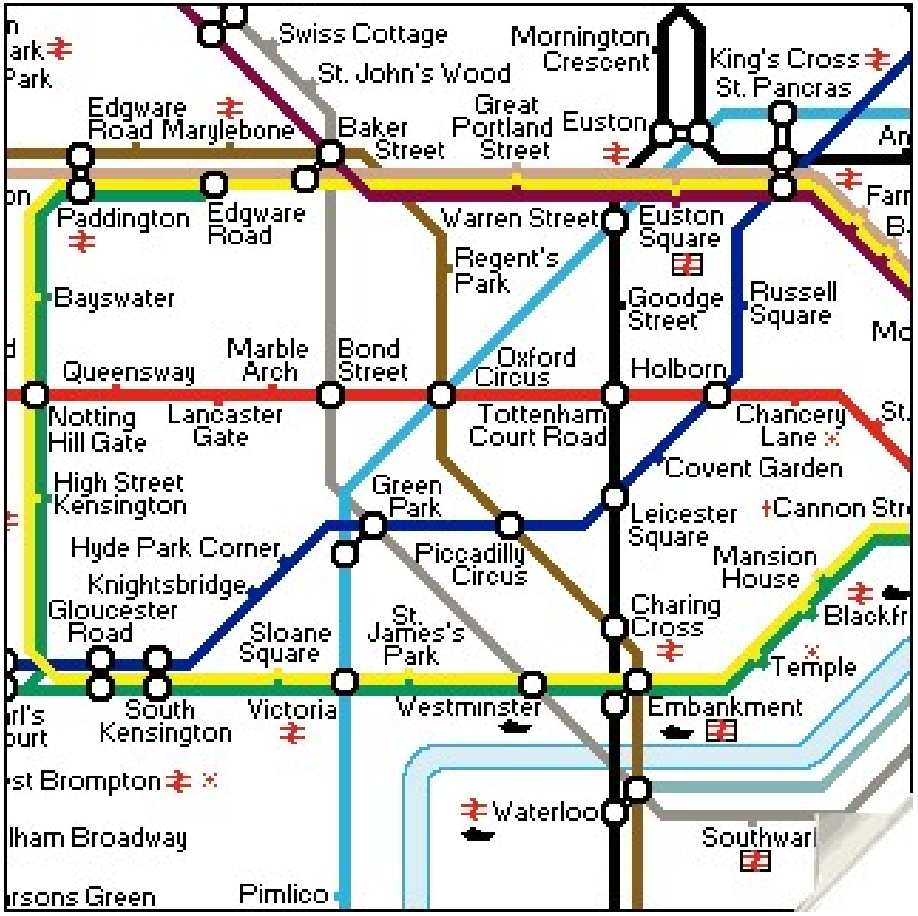
รู้ได้อย่างไรว่า High abstraction?



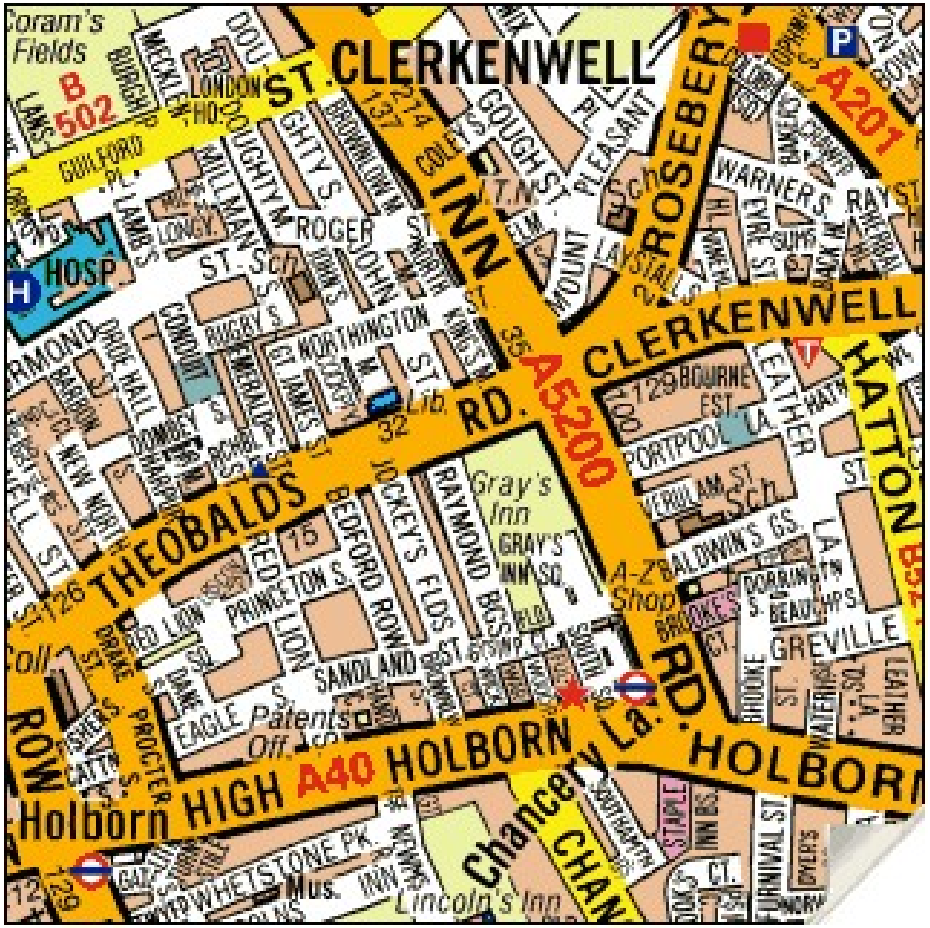
Level of Abstraction: High

Level of Abstraction: Low

Level of Abstraction: High

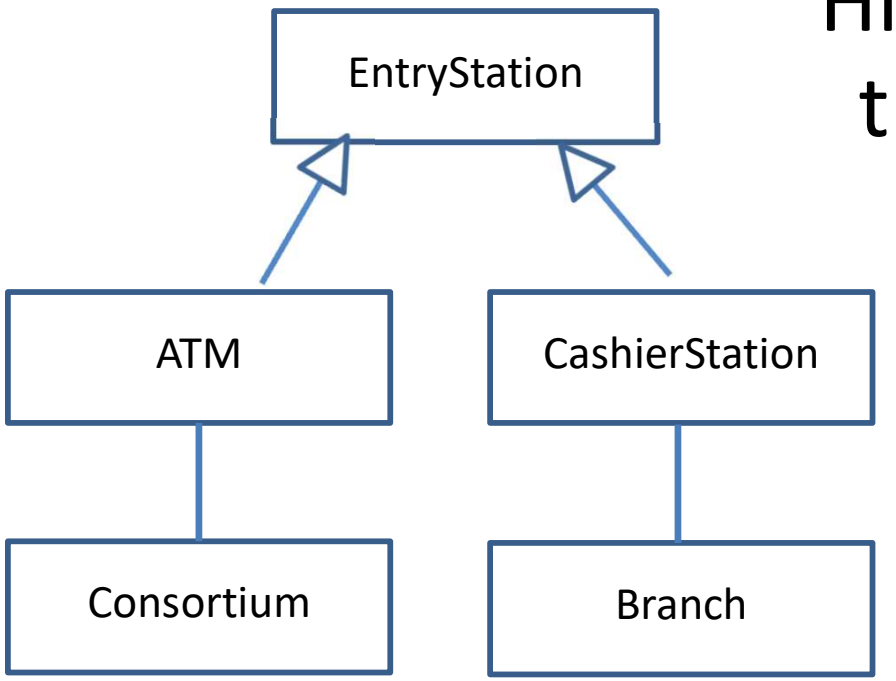


Level of Abstraction: Low



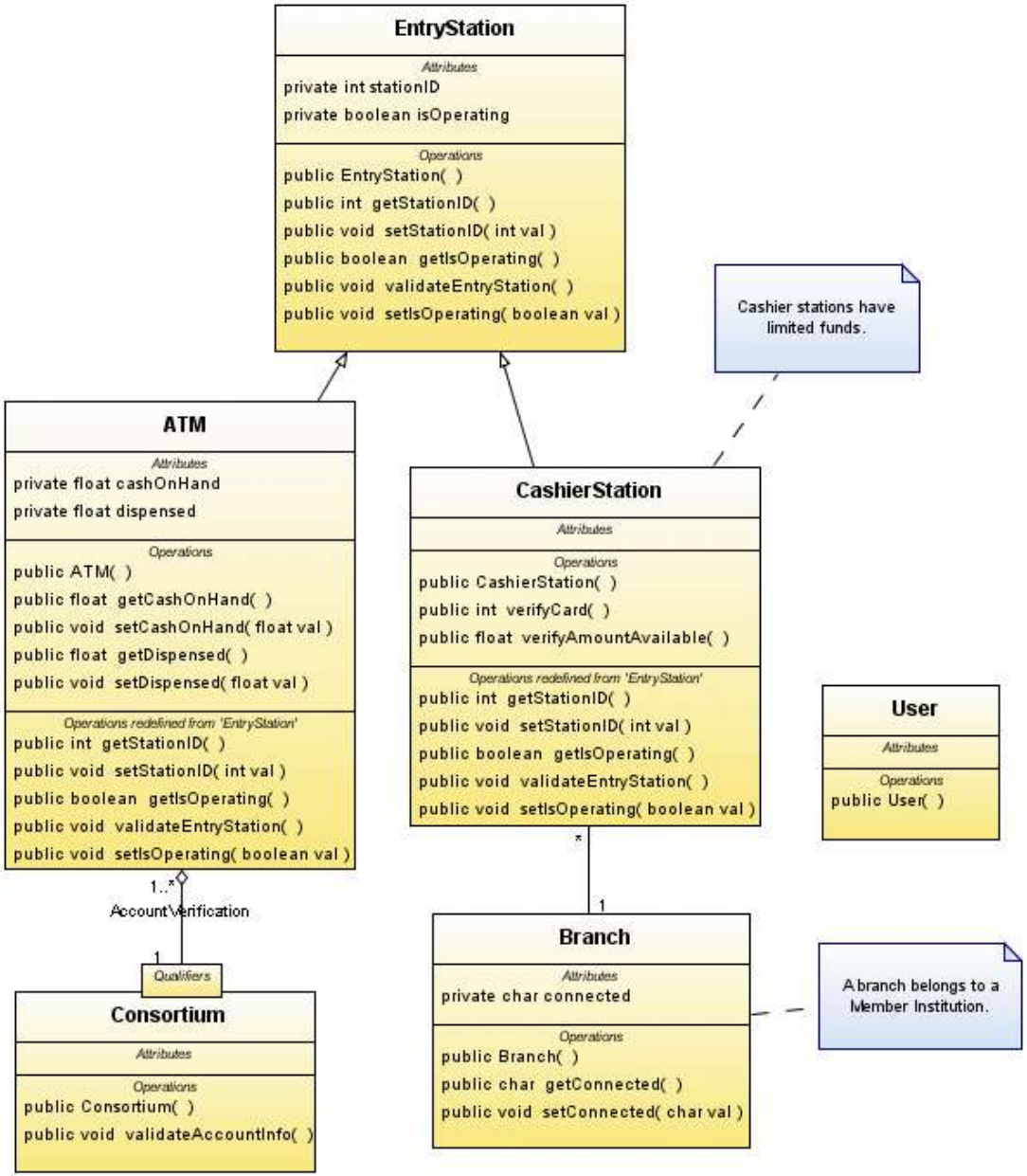
Hiding and Omitting to Reduce the Complexity of the Model

Hiding and Omitting to Reduce the Complexity of the Model



No details of classes

Q: เวลาแก้ไขเปลี่ยนแปลง scope ภาพใดแก้ไขง่ายกว่า?



คำถามที่ควรตอบได้

- Model คืออะไร
- Model สำคัญอย่างไร
- Informal model → Semi formal model → Formal model คืออะไร

WHAT

นิยามของ SW Arch

Computer scientist Ralph Johnson, who co-authored *Design Patterns: Elements of Reusable Object-Oriented Software*, once said:

"Architecture is about the important stuff. Whatever that is."

- Ralph E. Johnson

ความหมายแบบง่าย ๆ ตรง ๆ ไม่เป็นทางการนัก

About Software Architecture

- The extension of software engineering discipline
- Software Architecture presents a view of software system as components and connectors
  - Components encapsulate some coherent set of functionality
  - Connectors realize the runtime interaction between components

Architecture เน้น Abstraction level สูง

IEEE 1471-2000

"Architecture is defined by the recommended practice as the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution."

[ANSI/IEEE Std 1471-2000, *Recommended Practice for Architectural Description of Software-Intensive Systems*]

Bass, Clements, Kazman, 2003

"The software architecture of a program or computing system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them."

[L.Bass, P.Clements, R.Kazman, *Software Architecture in Practice (2nd edition), Addison-Wesley 2003]*

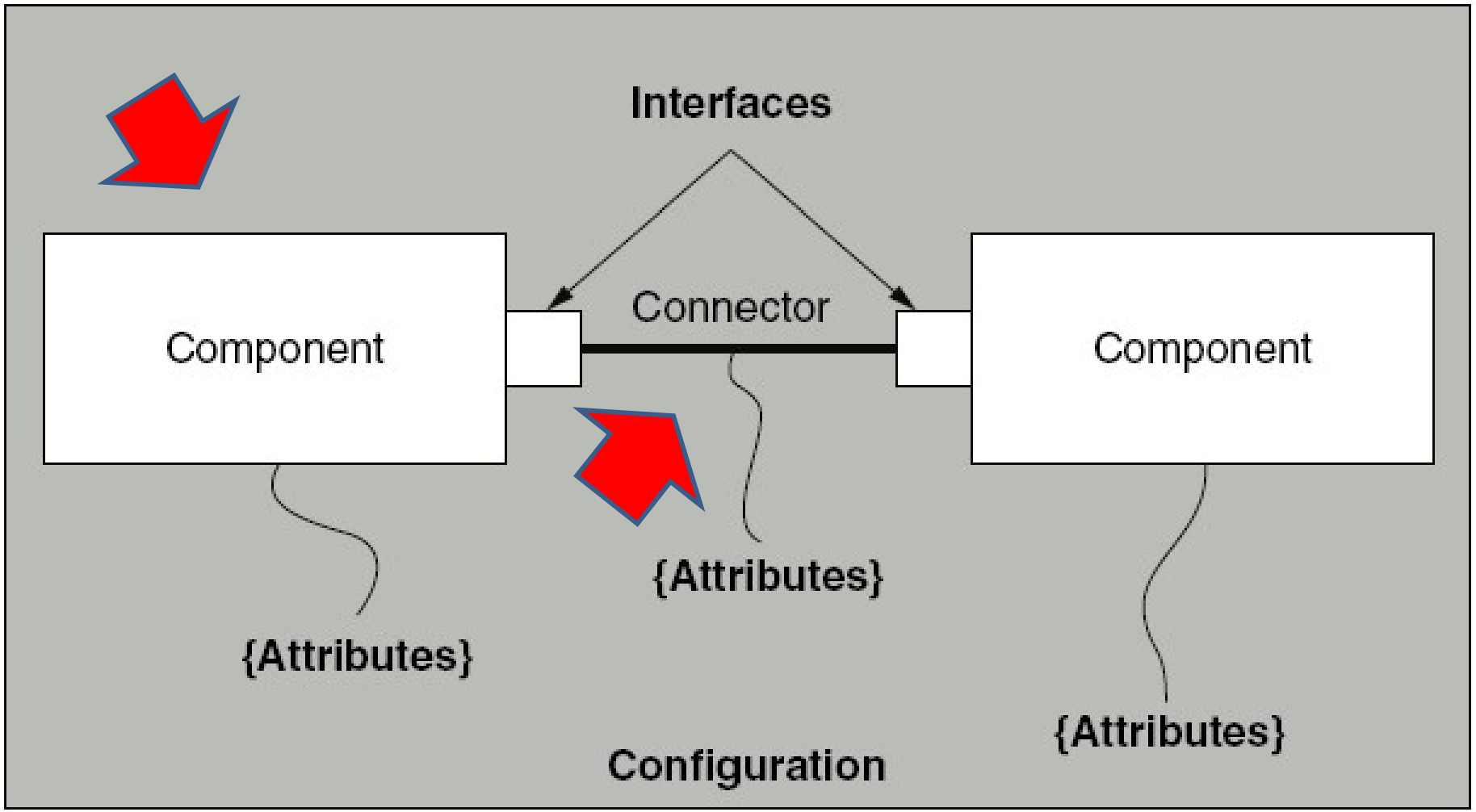


Figure 12-1. Software architecture concept.

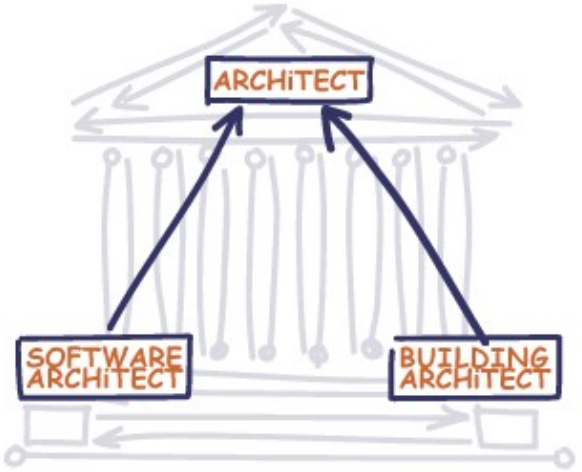
กล่าวได้ว่า

- สำหรับ Software Architecture เราใช้ model ที่เขียนด้วย
  - UML Subsystem diagram (design-time)
  - UML Component diagram (run-time)

SW Arch ควรมีกี่ diagram?

แต่ละ diagram แสดงถึงมุมมอง View ที่แตกต่างกัน ไม่จำเป็นต้องใช้แค่ diagram เดียว

Worldwide Institute of Software Architect (www.wwisa.org)



WWISA
WORLDWIDE INSTITUTE OF SOFTWARE ARCHITECTS

ตย. องค์กรด้าน Sw Arch

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- The Institute of Software Architects, Inc. is a nonprofit corporation founded to accelerate the establishment of the profession of software architecture and to provide information and services to software architects and their clients.

HOW

เราออกแบบและนำเสนอ SW Arch ได้อย่างไร

Architectural Representation and Documentation

Software Architecture Description

= A set of practice for expressing, communicating, and analyzing software architecture.

- เราบันทึก Software architecture ด้วยการอธิบาย
- เรานิยมเลือกวิธีการอธิบายด้วยแผนภาพและข้อความสั้น ๆ ประกอบกัน (Semi formal model)
- ในอีกนัยหนึ่ง
  Architecture Description = Architecture Modelling นั่นเอง

What if Software Architecture shown in source code

Source Code Represents Architecture?

ทำไม ใช้ยาก

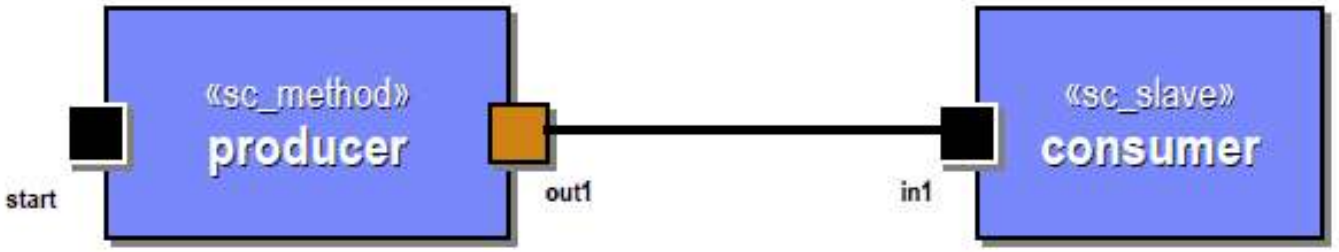
A Bit of Modern Software…

```
SC_MODULE(producer)
{
sc_outmaster<int> out1;
sc_in<bool> start; // kick-start
void generate_data ()
{
for(int i =0; i <10; i++) {
out1 =i ; //to invoke slave;}
}
SC_CTOR(producer)
{
SC_METHOD(generate_data);
sensitive << start;}};
SC_MODULE(consumer)
{
sc_inslave<int> in1;
int sum; // state variable
void accumulate (){
sum += in1;
cout << "Sum = " << sum << endl;}
SC_CTOR(consumer)
{
SC_SLAVE(accumulate, in1);
sum = 0; // initialize
};
SC_MODULE(top) // container
{
producer *A1;
consumer *B1;
sc_link_mp<int> link1;
SC_CTOR(top)
{
A1 = new producer("A1");
A1.out1(link1);
B1 = new consumer("B1");
B1.in1(link1);}};
```

Can you spot the architecture?

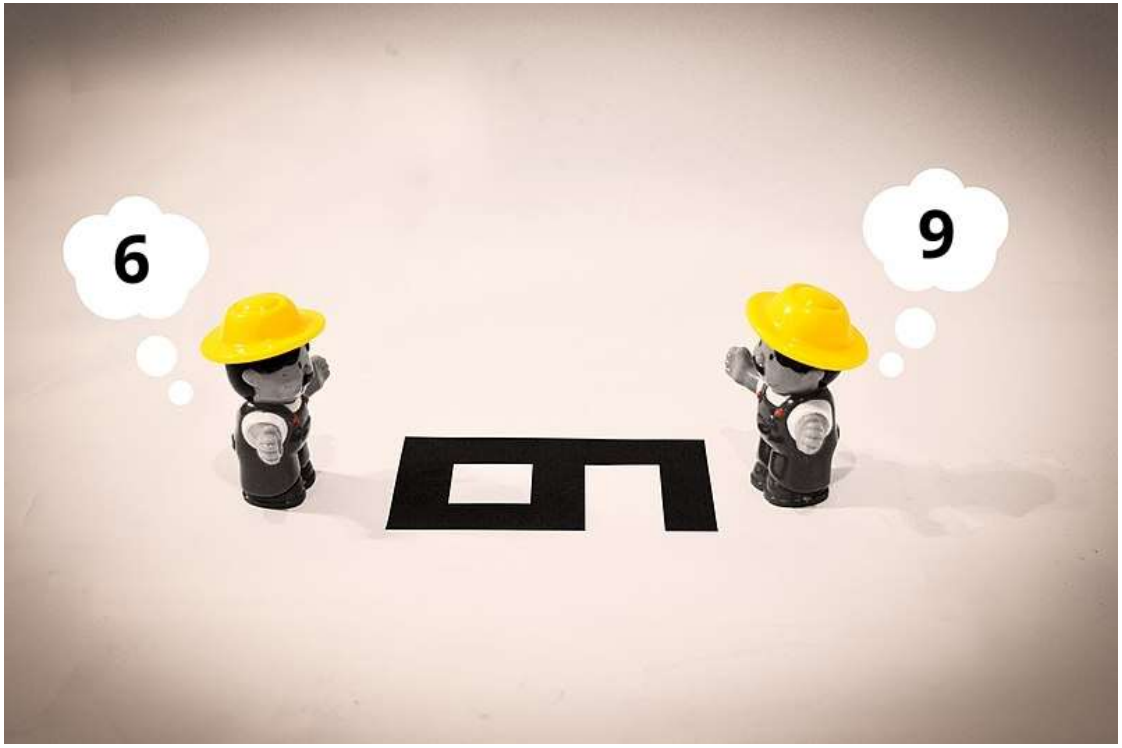
ถ้าเราใช้ UML จะง่ายในการเข้าใจภาพรวม

…and its UML 2.0 Model



Can you see it now?

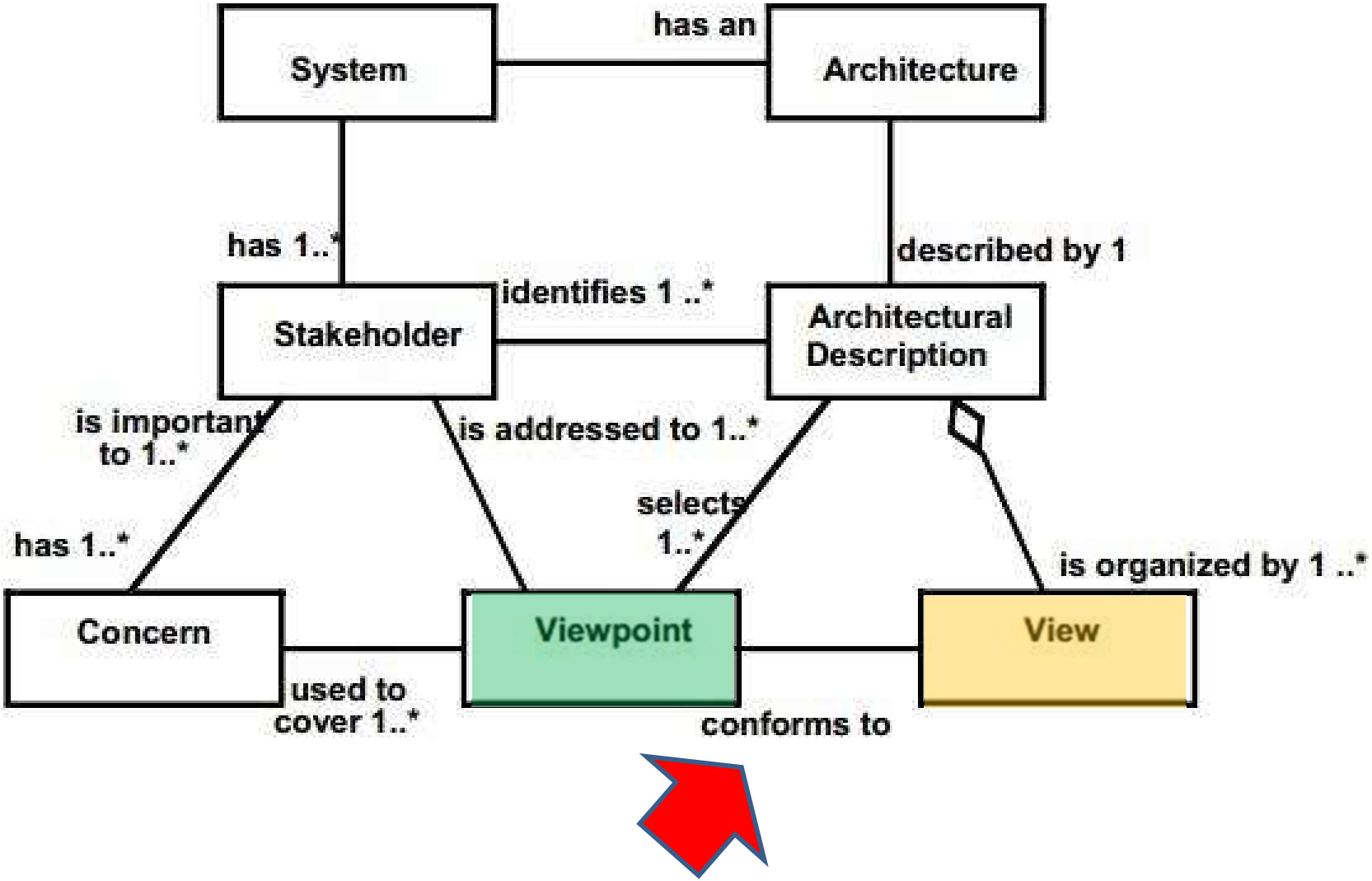
Architectural Views
vs.
Architectural Viewpoints



Architecture Viewpoints

- Software architecture descriptions are organized into Views.
- Each view addresses a set of system concerns
- Each view is drawn following the conventions of its viewpoint.
- A viewpoint is a specification that describes the notations, modeling techniques to be used in a view to express the architecture.
- Viewpoints are generic templates, while views are what you actually see.

From ISO 42010 *Systems and software engineering*



Examples of Viewpoints

- Functional viewpoint
- Logical viewpoint
- Information/Data viewpoint
- Module viewpoint
- Component-and-connector viewpoint
- Requirements viewpoint
- Security viewpoint
- Physical/Deployment/Installation viewpoint
- Etc.

Viewpoint = แม่แบบวิธีเขียน view สำหรับมุมมองนั้น
เช่น ที่ Functional viewpoint จะได้ Func.view, etc.

Architectural Views

- Many possible “views” of architecture
  - Implementation structures
    - Modules, packages
    - Modifiability, Independent construction, …
  - Run-time structures
    - Components, connectors
    - Interactions, dynamism, reliability, …
  - Deployment structures
    - Hardware, processes, networks
    - Security, fault tolerance, …

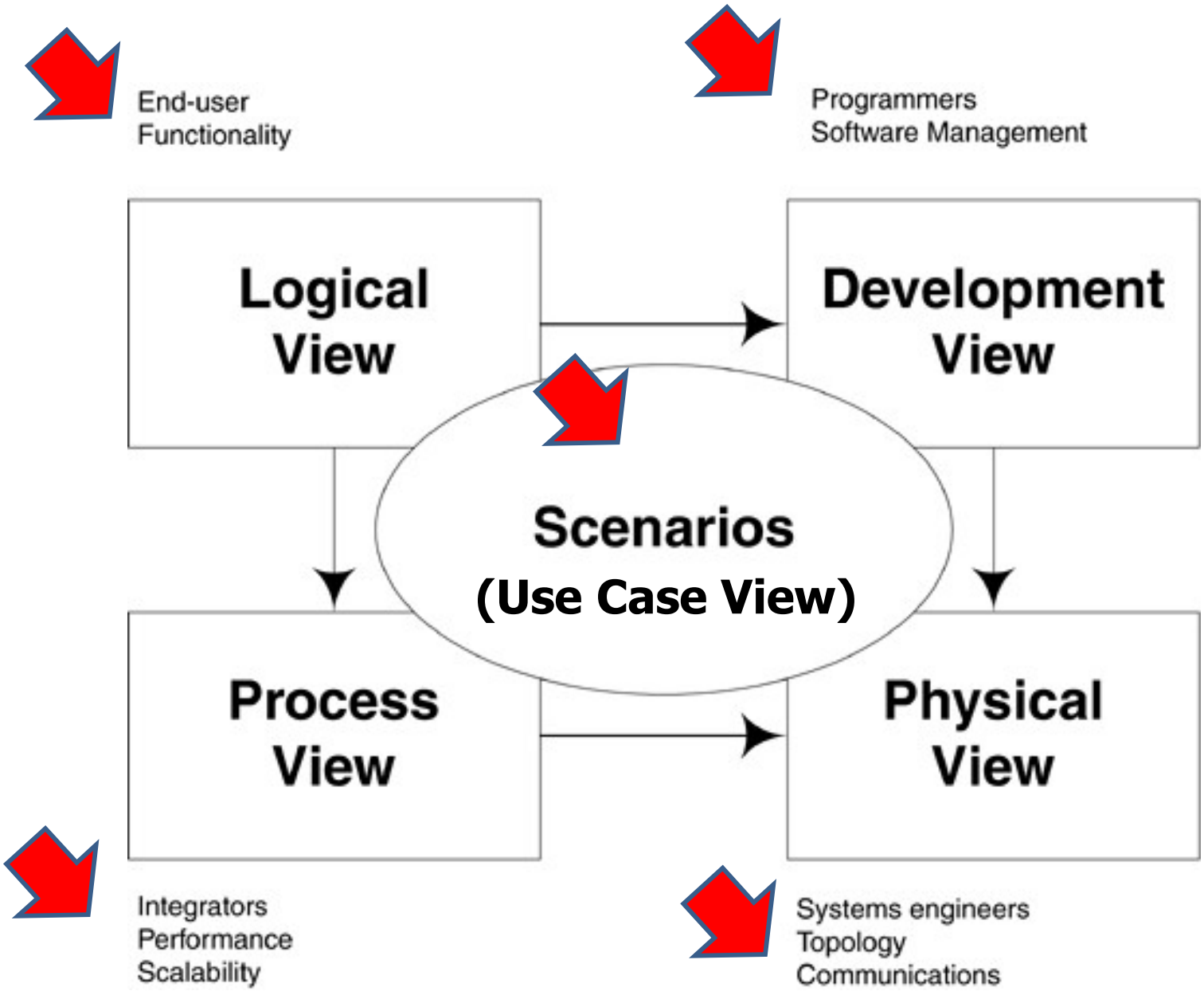
How many views?

- 5 by Taylor et al.: Logical, Physical, Deployment, Concurrency, Behavioral
- 3 by Bass et al.: Component & Connector, Module View, Behavior
- 4+1 by Kruchten: Logical, Physical, Process, Development, and Scenarios
- C4 Model by xxxxxxx: ….
- Our class aims to use C4+Sequence diagram

4+1 Architecture Views

- The term “architecture views” rose to prominence in Philippe Kruchten’s 1995 paper on the 4+1 View Model
- This presented a way of describing and understanding an architecture based on the following four views:
  - Logical View
  - Process View
  - Development View
  - Physical View
  - Tied together by Use Case View

The 4+1 Architectural View by Krutchen

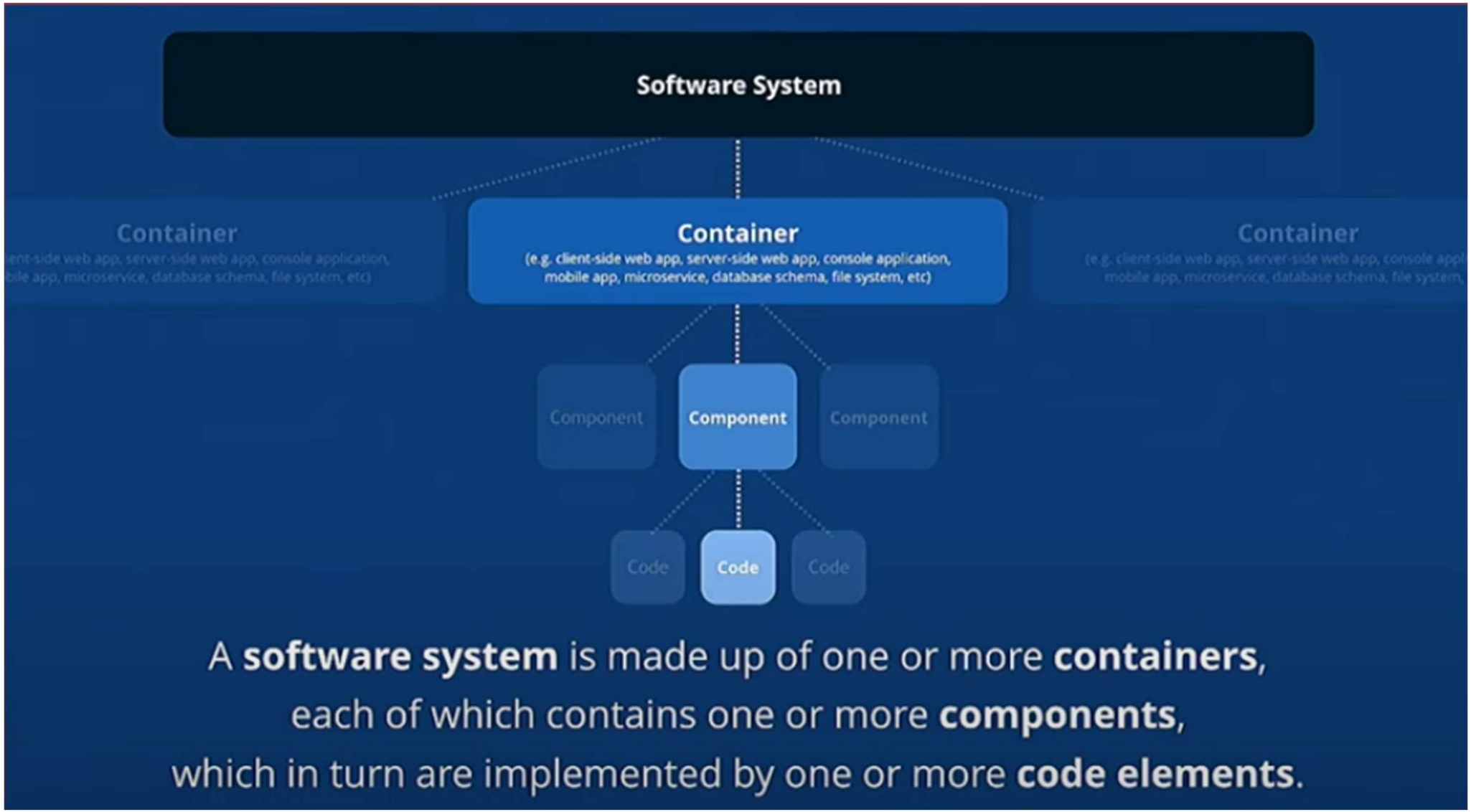


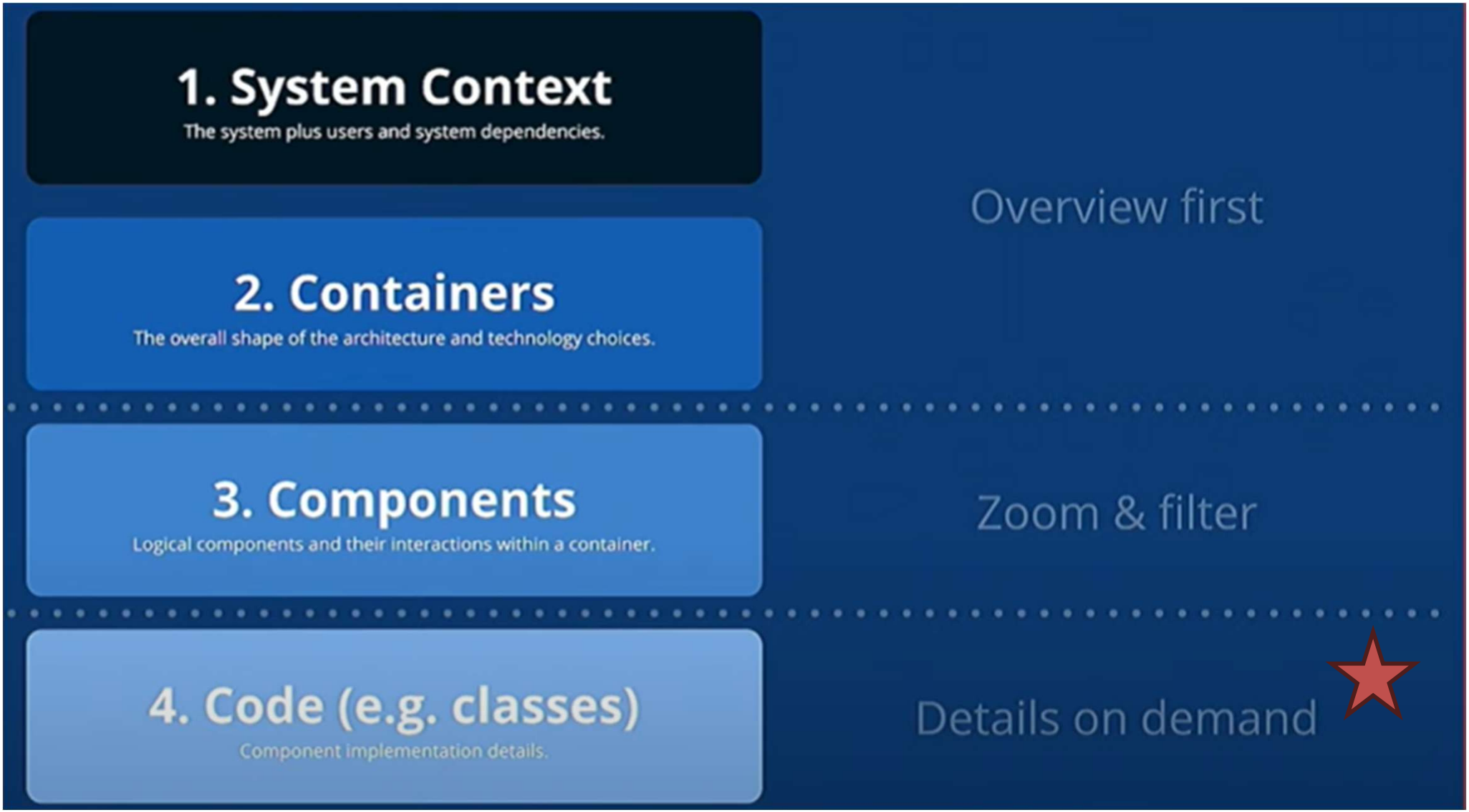
C4 Model

- The C4 model for software architecture was created by Simon Brown
- He developed it between 2006 and 2011, drawing inspiration from the Unified Modeling Language (UML) and the 4+1 architectural view model
- Simon Brown aimed to create a simpler and more effective way to visualize and communicate software architecture, especially for agile teams

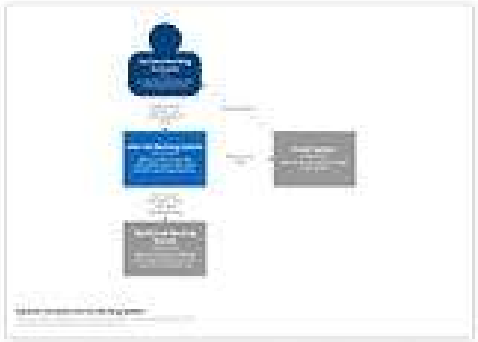
https://c4model.com/

การทำ Abstraction โดย C4 Model

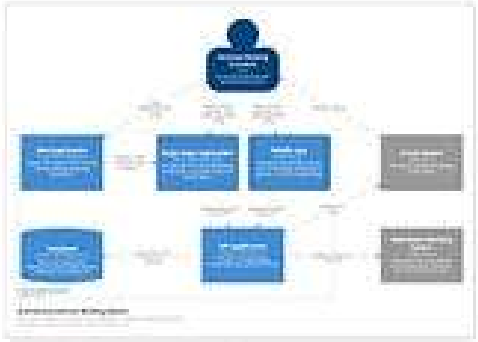



1. System Context
The system plus users and system dependencies.
2. Containers
The overall shape of the architecture and technology choices.
3. Components
Logical components and their interactions within a container.
4. Code (e.g. classes)
Component implementation details.
Overview first
Zoom & filter
Details on demand

เปรียบกับการทำ Zoom In/Out

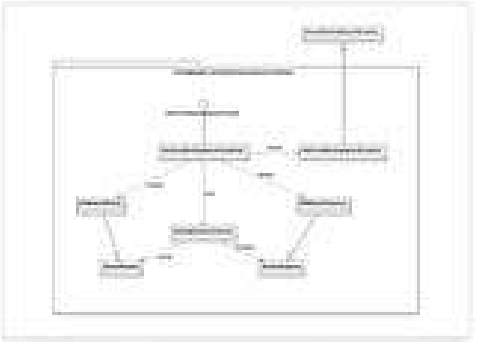


Level 1: A **System Context** diagram provides a starting point, showing how the software system in scope fits into the world around it.



Level 2: A **Container** diagram zooms into the software system in scope, showing the high-level technical building blocks.

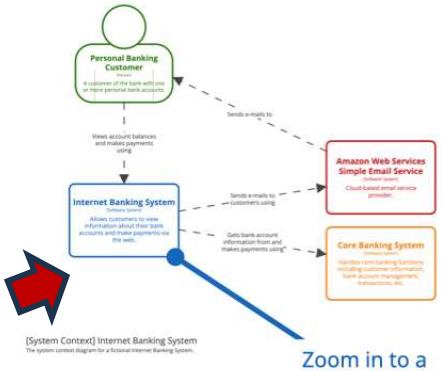
Level 3: A **Component** diagram zooms into an individual container, showing the components inside it.



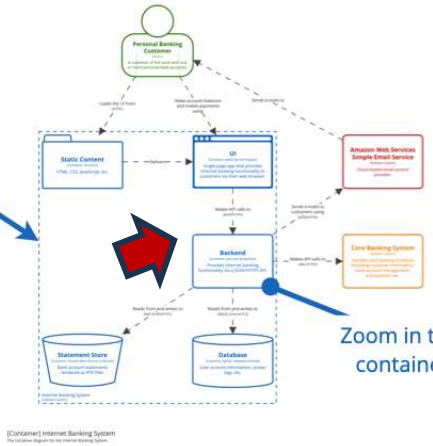
Level 4: A **code** (e.g. UML class) diagram can be used to zoom into an individual component, showing how that component is implemented.

The C4 model for visualising software architecture

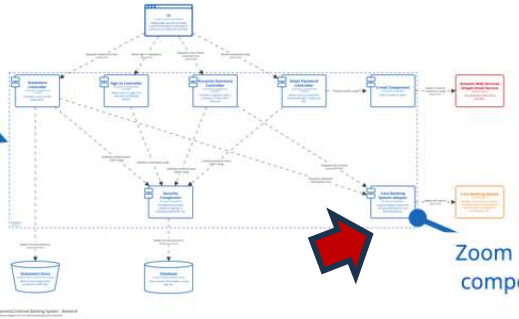
c4model.com



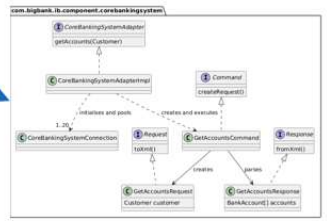
Zoom in to a software system



Zoom in to a container

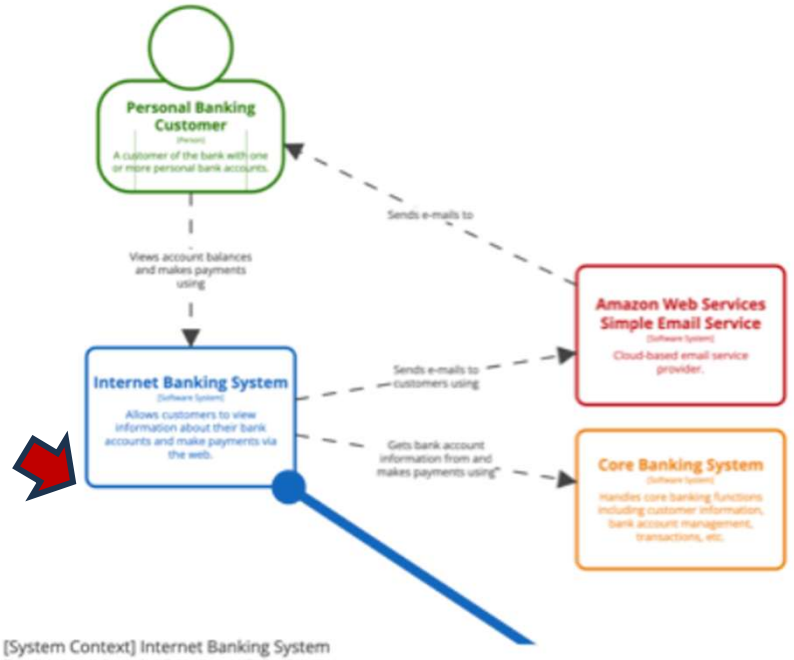


Zoom in to a component



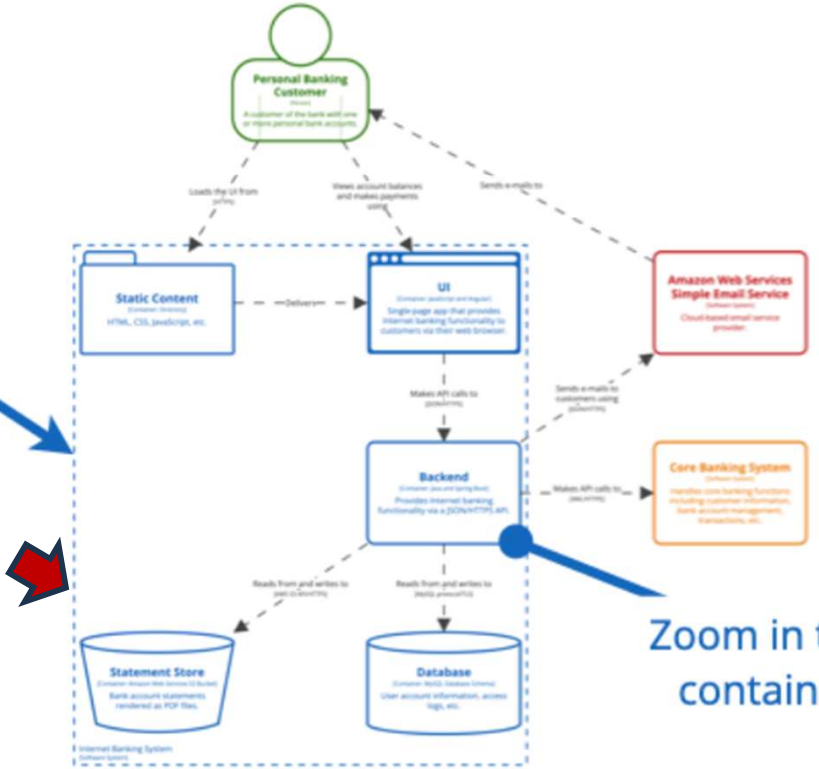
1. Context
2. Containers
3. Components
4. Code

The C
sc



[System Context] Internet Banking System
The system context diagram for a fictional Internet Banking System.

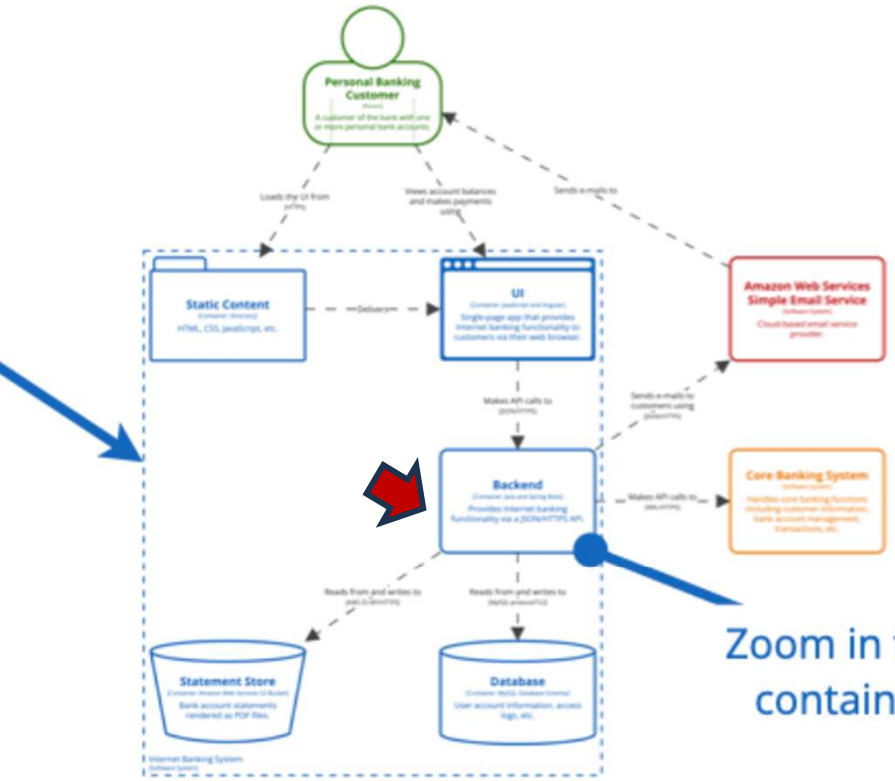
Zoom in to a software system



[Container] Internet Banking System
The container diagram for the Internet Banking System.

Zoom in to a container

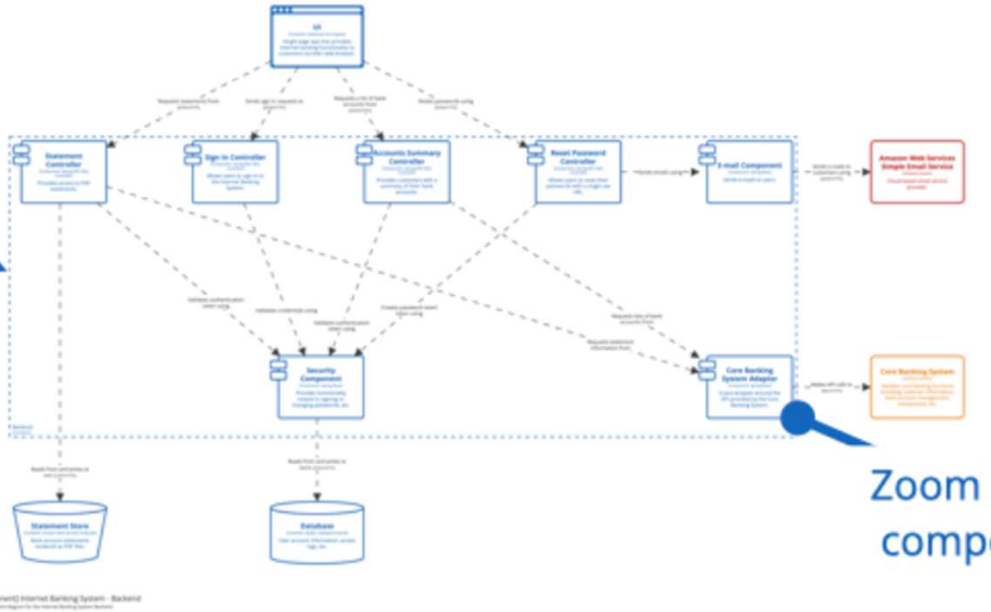
c4model.com



[Container] Internet Banking System

The container diagram for the Internet Banking System.

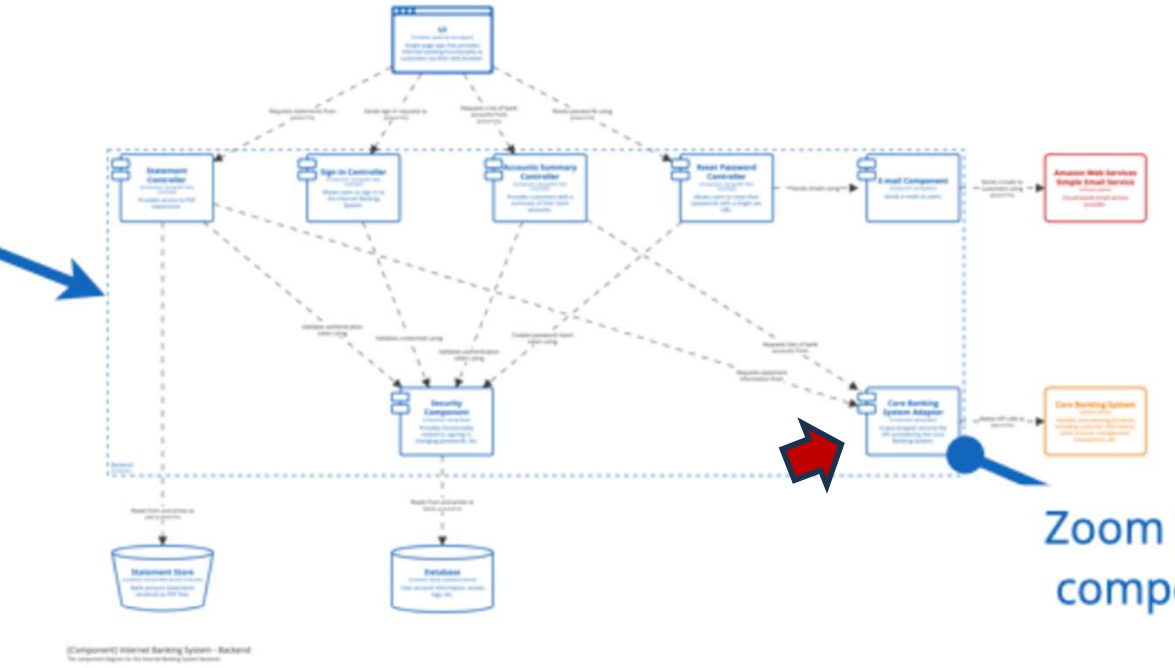
Zoom in to a container



[Component] Internet Banking System - Backend

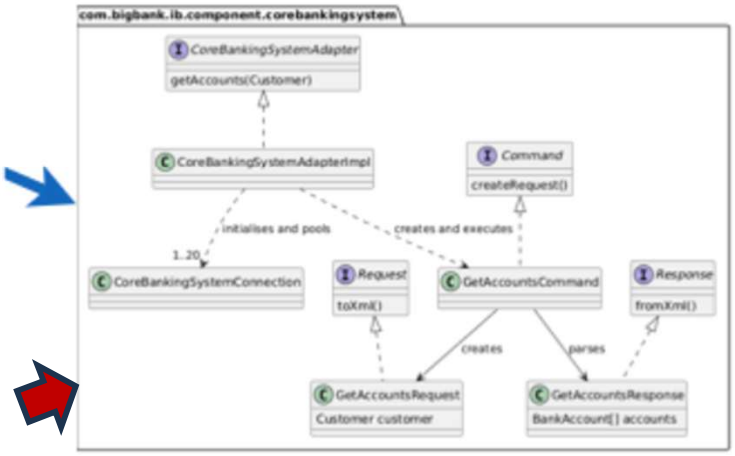
The component diagram for the Internet Banking System's Backend.

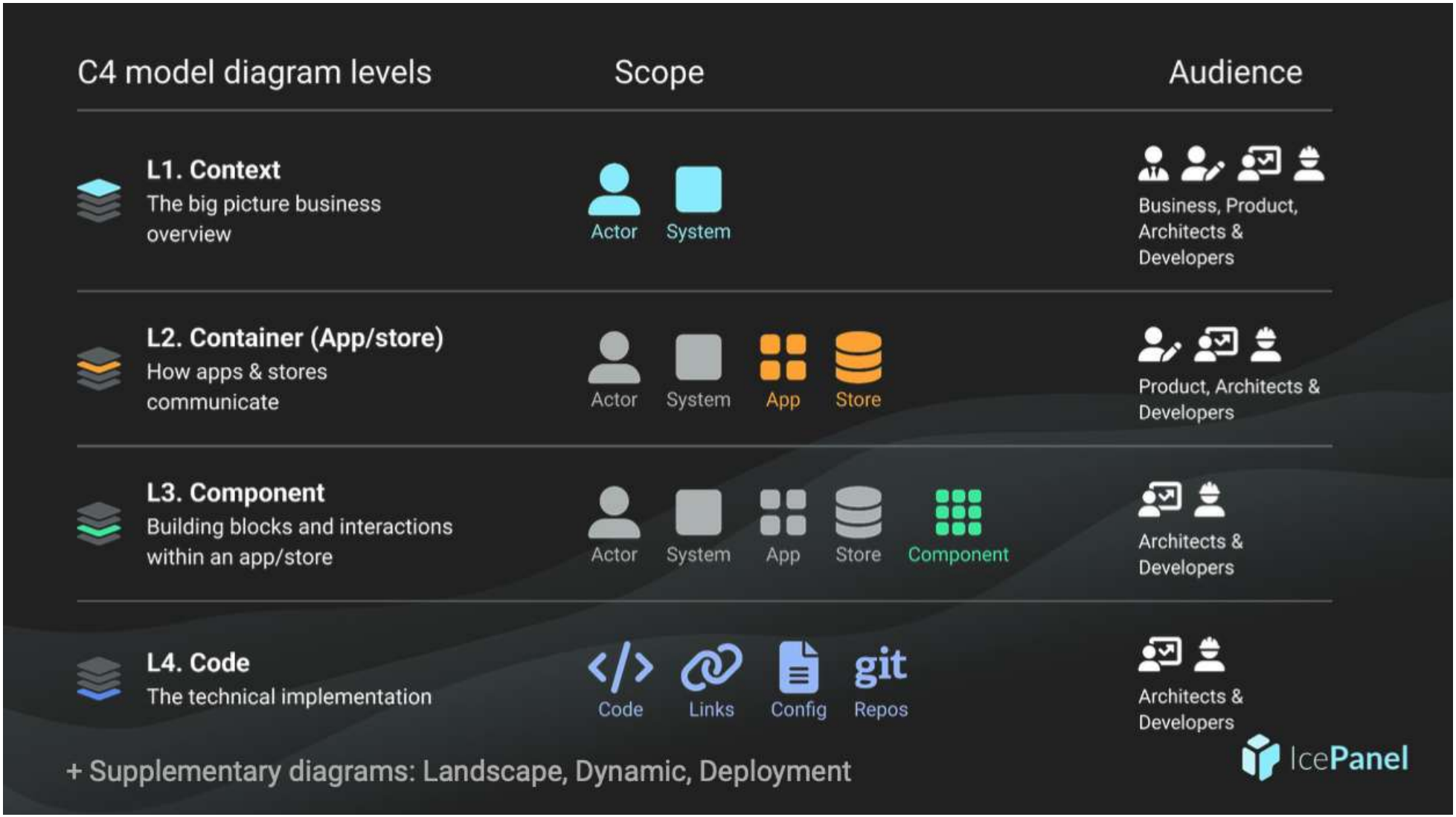
Zoom i
compo



Zoom in to a component

(Brown said "don't recommended" on demand only)



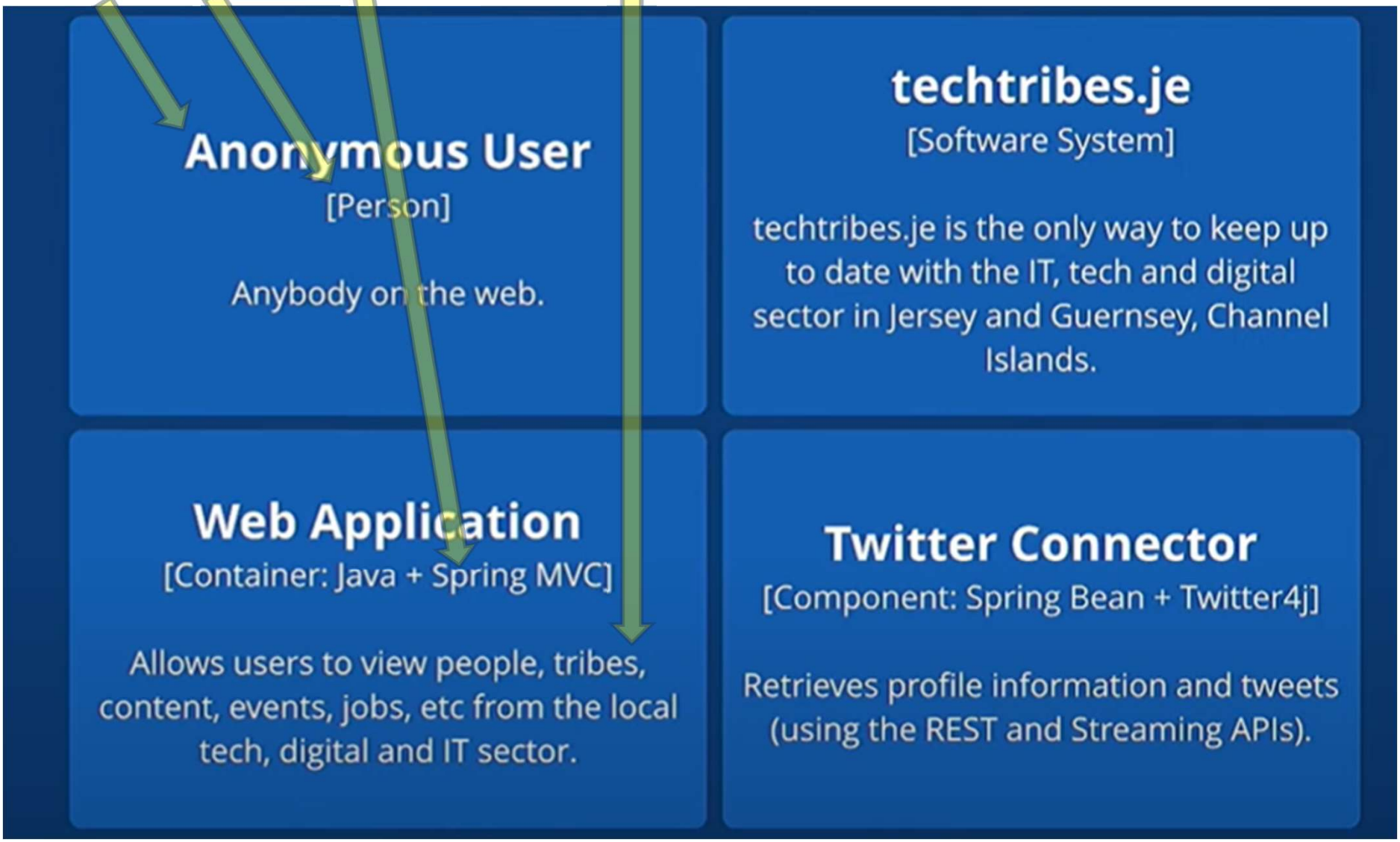

C4 model diagram levels
Scope
Audience
L1. Context
The big picture business overview
Actor
System
Business, Product, Architects & Developers
L2. Container (App/store)
How apps & stores communicate
Actor
System
App
Store
Product, Architects & Developers
L3. Component
Building blocks and interactions within an app/store
Actor
System
App
Store
Component
Architects & Developers
L4. Code
The technical implementation
Code
Links
Config
Repos
Architects & Developers
+ Supplementary diagrams: Landscape, Dynamic, Deployment
IcePanel

Notation of Elements in the C4 Model

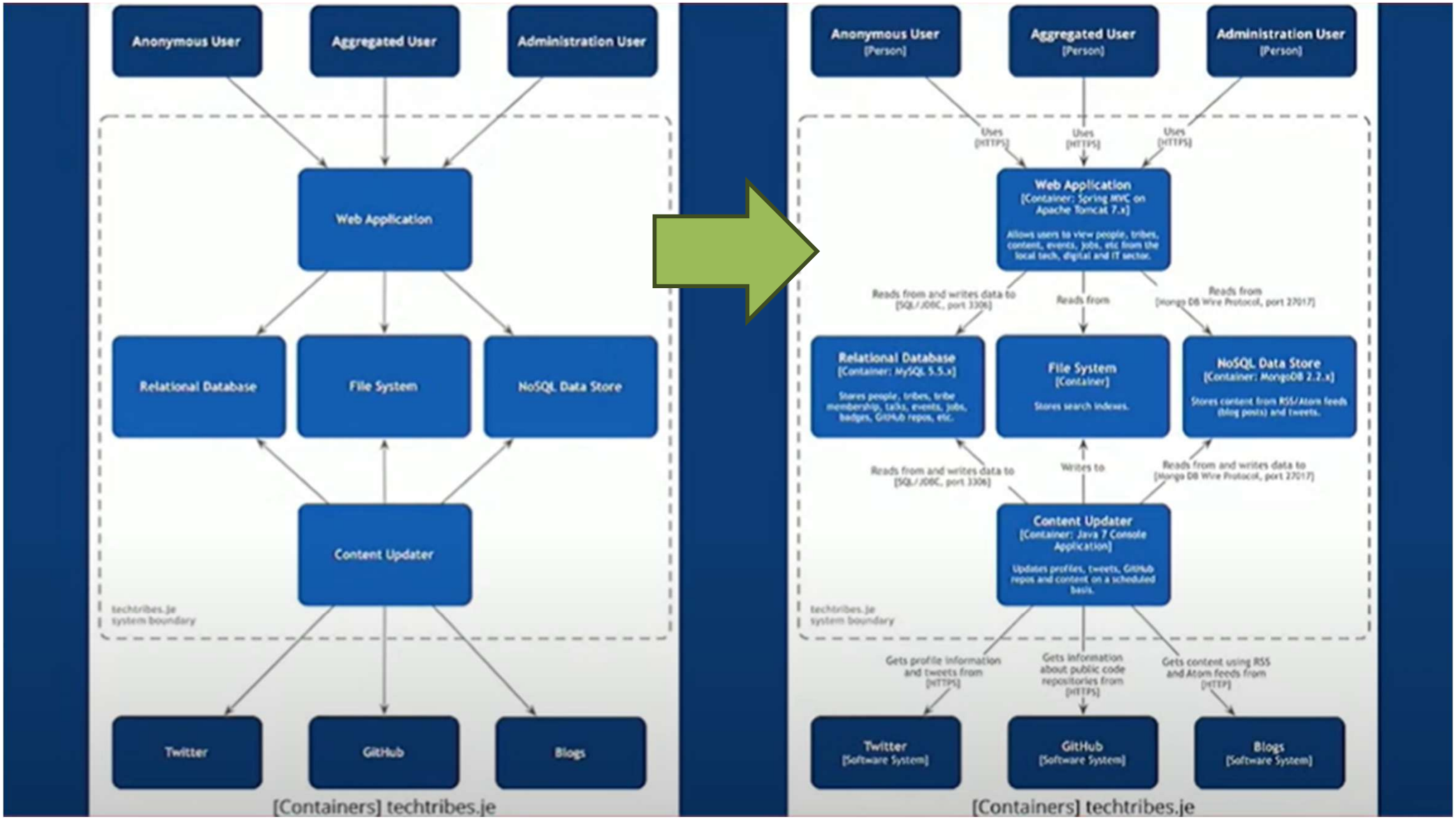
Lines

Favour uni-directional lines showing the most important dependencies or data flow, with an annotation to be explicit about the purpose of the line and direction

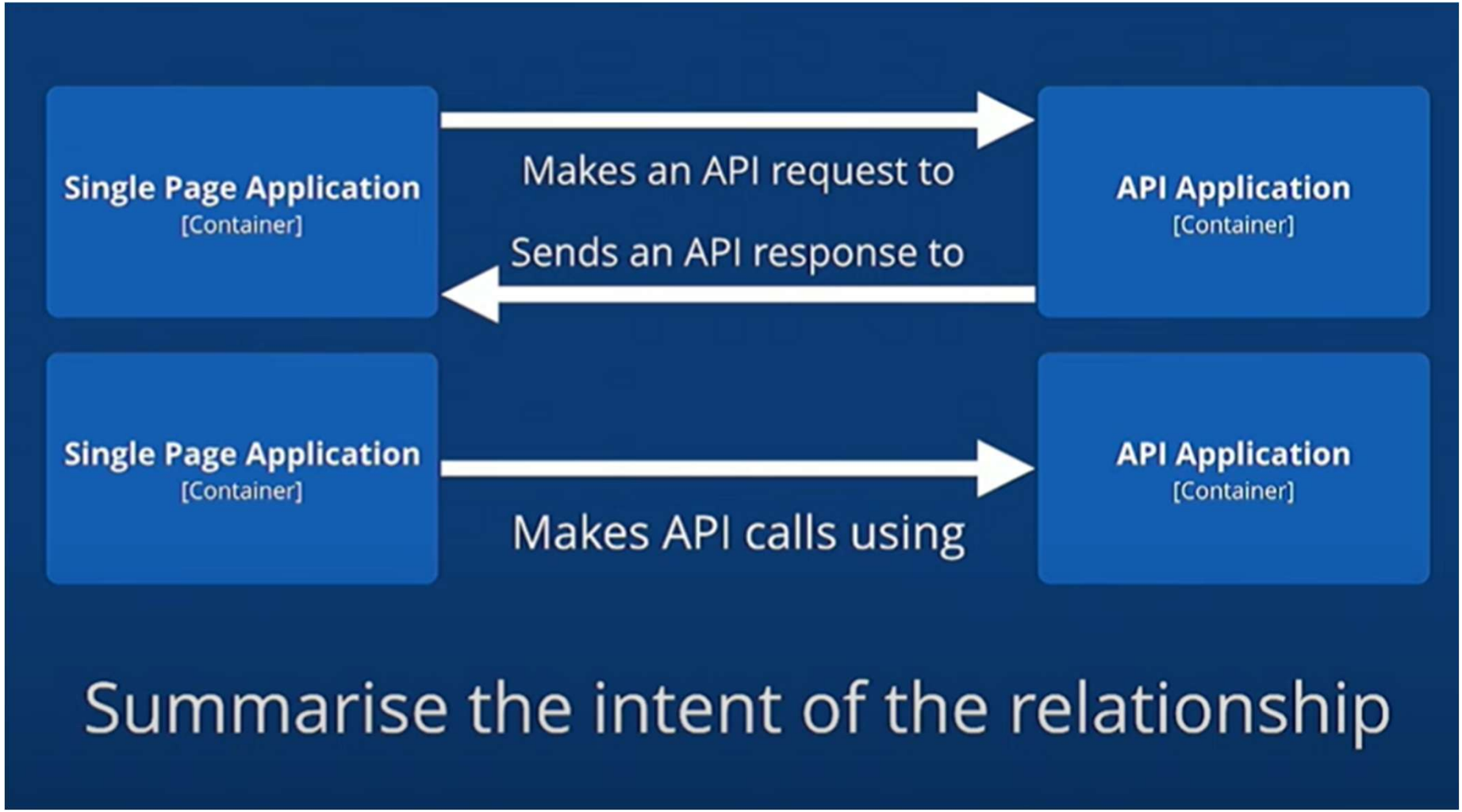
Name, Type, Technology, Description/Responsibility.



Elaborate the C4 Elements

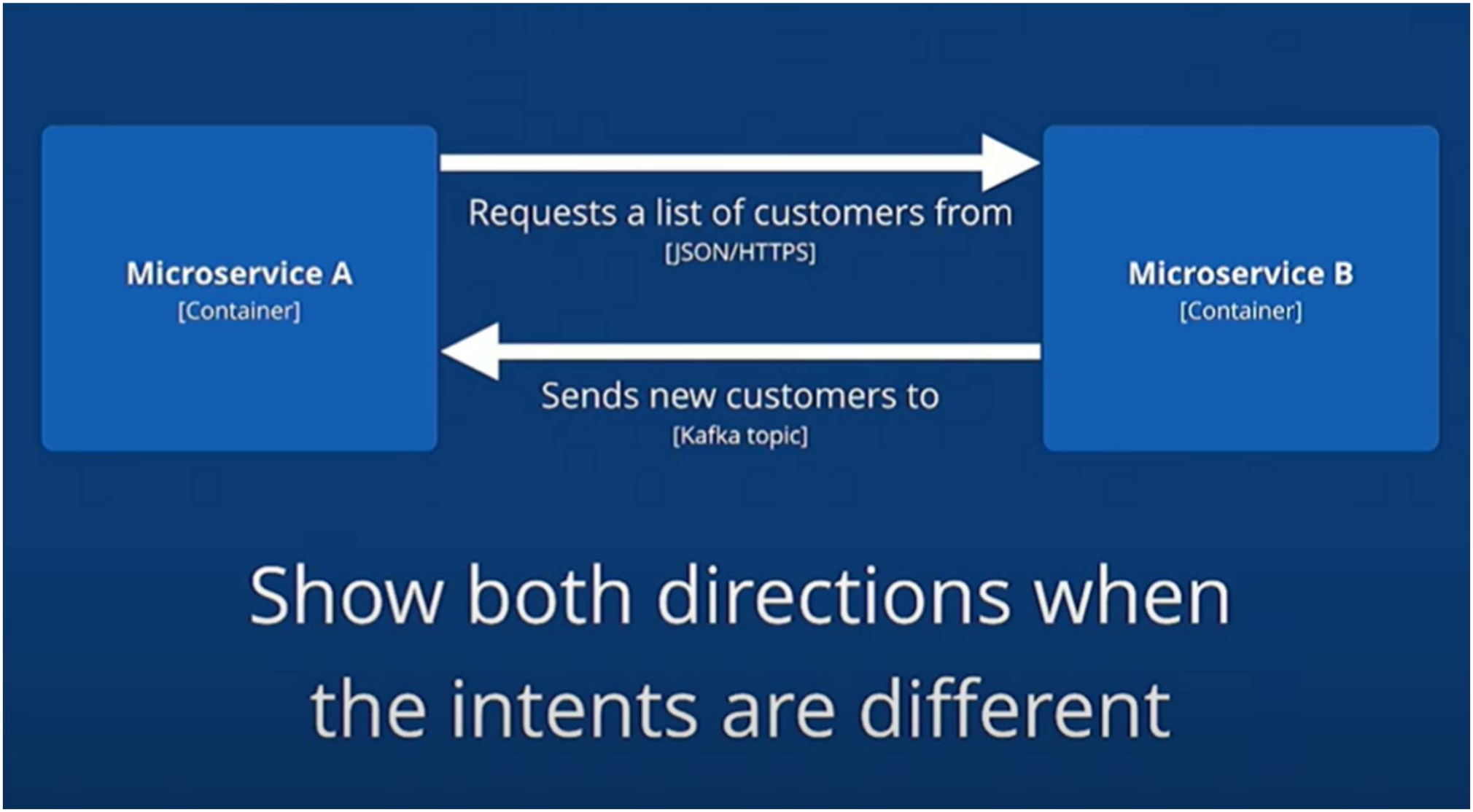


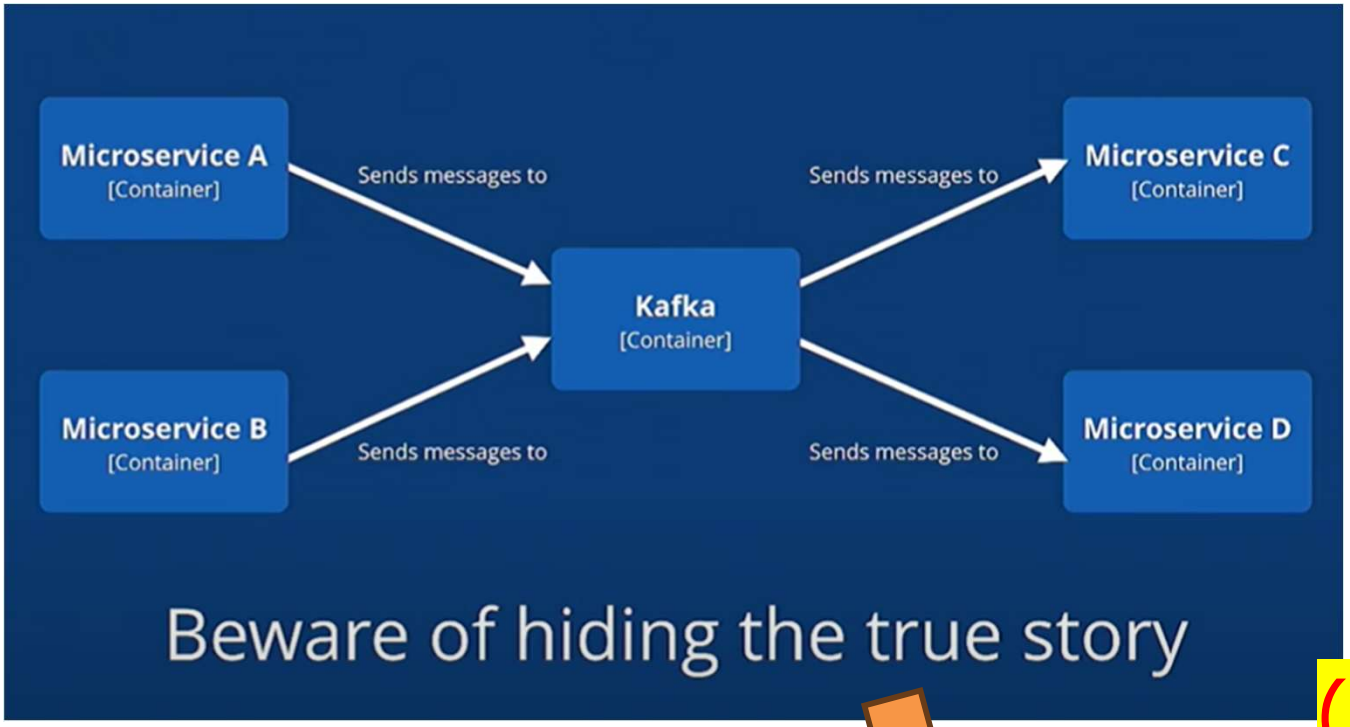
ลดจำนวนเส้นโดยการ Summarize



Only needed

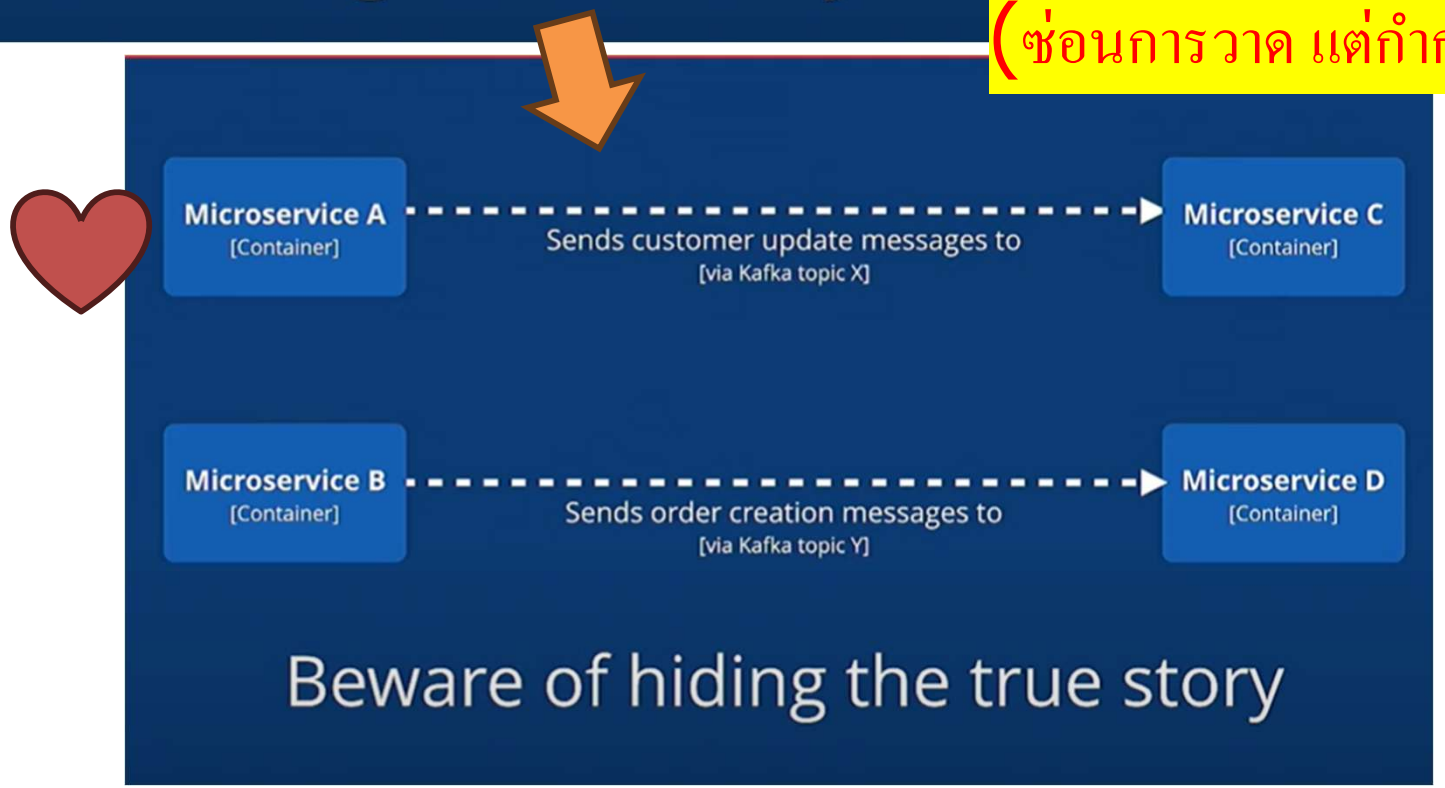
Different protocols





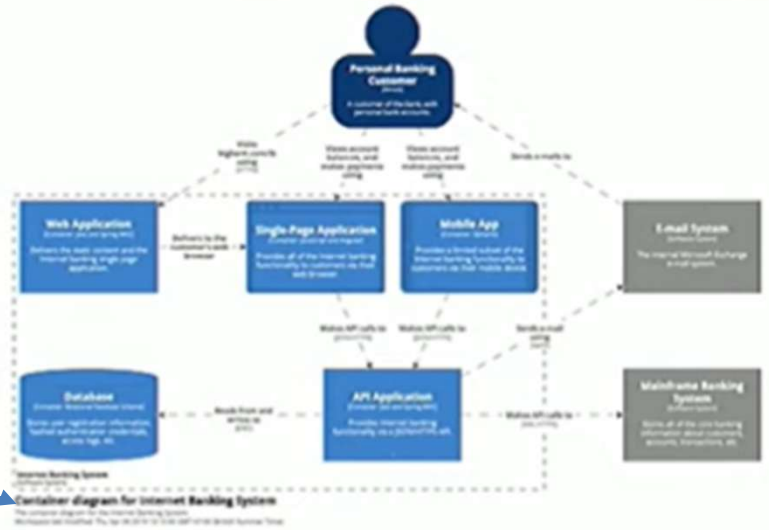
(ไม่ผิด แต่มองแล้วอาจจะเข้าใจผิดว่าเป็น Hub and Spoke)

(ซ่อนการวาด แต่กำกับเส้นแทน)

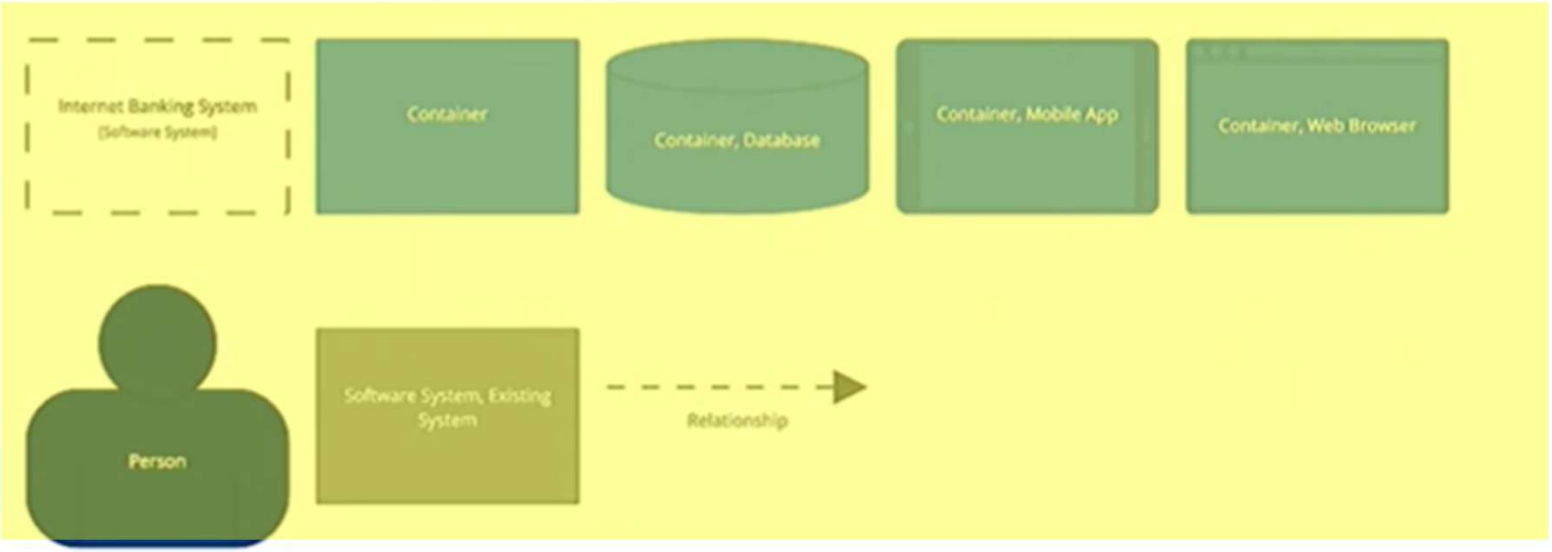


แนะนำใช้ Legend (การอธิบายสัญลักษณ์)

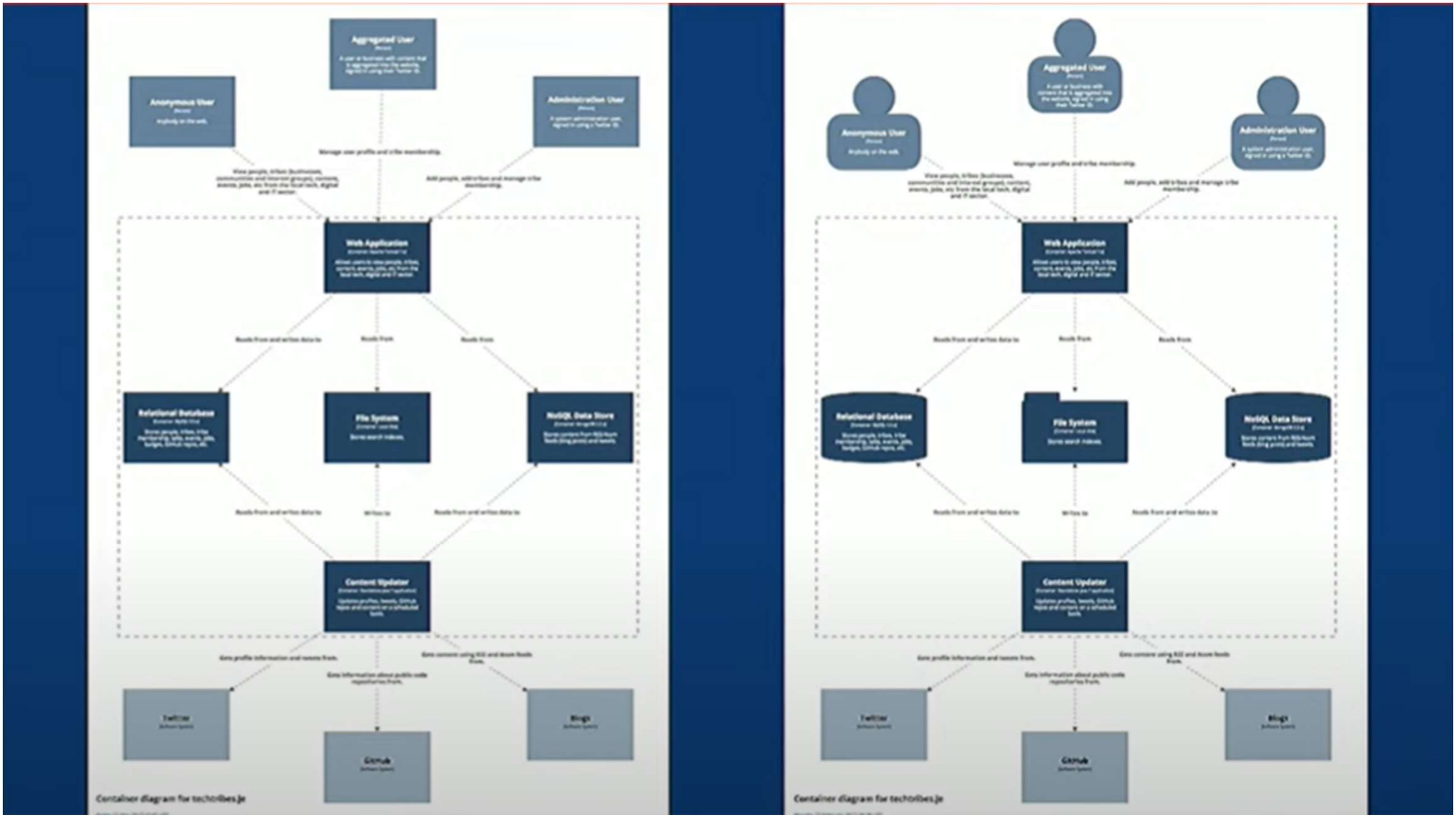
Title

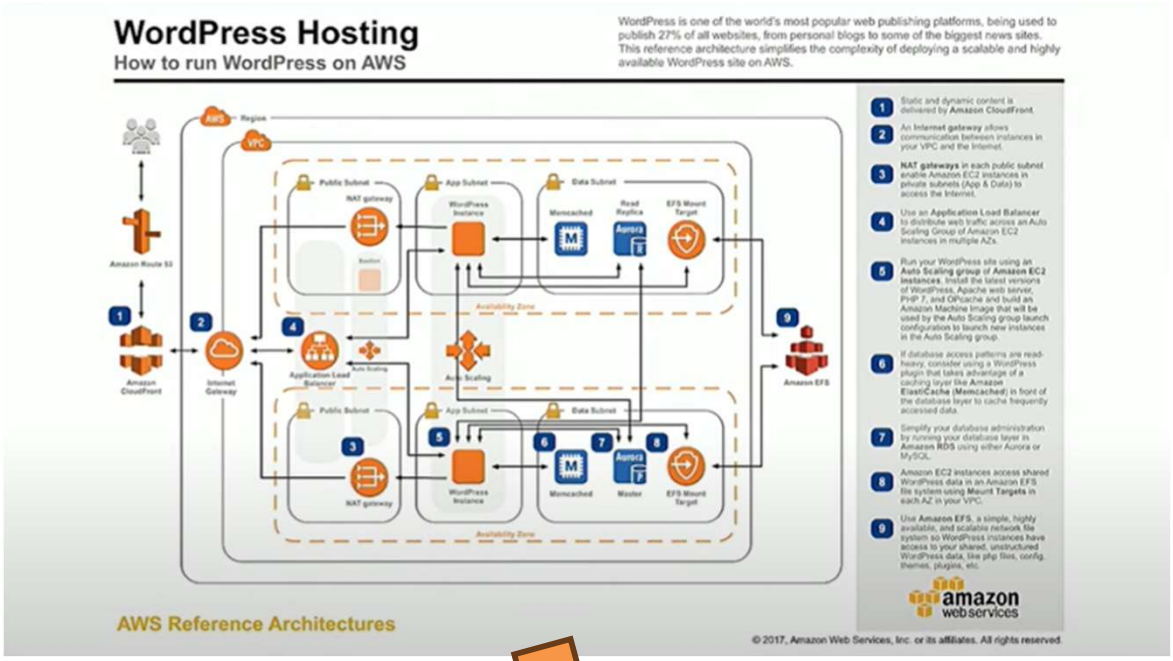


Legend

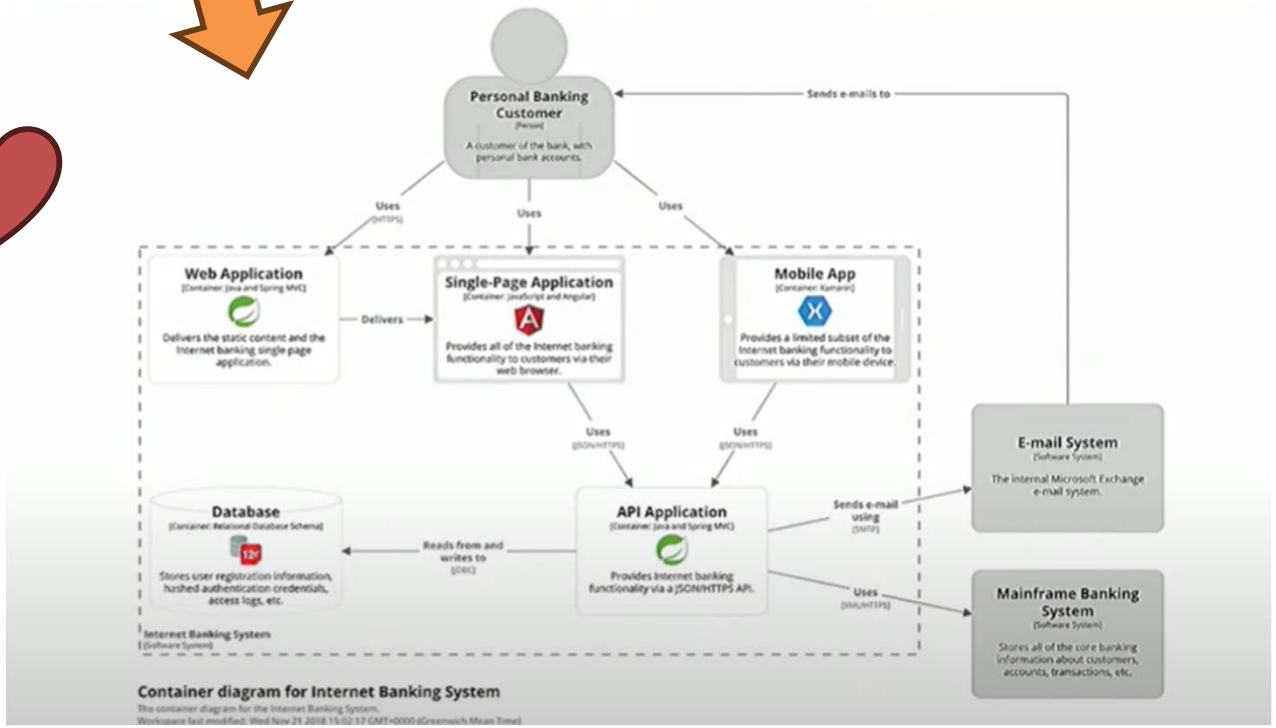


ใช้ Shape และ Color ช่วยให้อ่านง่าย





(อ่านยาก icon shape เยอะหลากหลาย ไม่มีคำอธิบาย)



Notation, notation, notation

A software architecture diagram review checklist

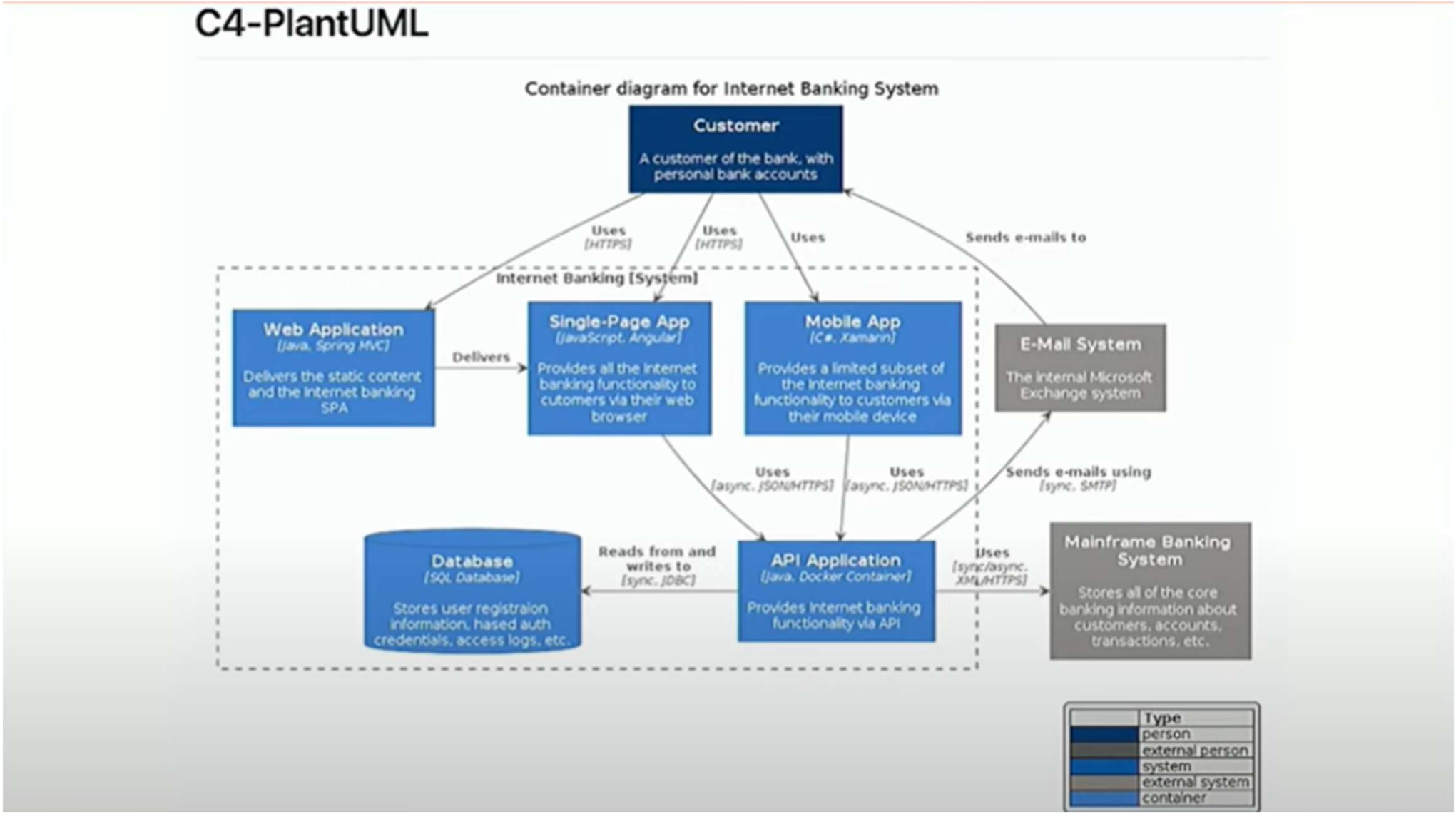
General

Does the diagram have a title?	Yes	No
Do you understand what the diagram type is?	Yes	No
Do you understand what the diagram scope is?	Yes	No
Does the diagram have a key/legend?	Yes	No

Elements

Does every element have a name?	Yes	No
Do you understand the type of every element? (i.e. the level of abstraction; e.g. software system, container, etc)	Yes	No
Do you understand what every element does?	Yes	No
Where applicable, do you understand the technology choices associated with every element?	Yes	No
Do you understand the meaning of all acronyms and abbreviations used?	Yes	No
Do you understand the meaning of all colours used?	Yes	No

Recommended Drawing Tool



A lightweight software architecture modelling tool, specifically designed to support the C4 model; supplemented with Markdown/AsciiDoc documentation, and architecture decision records (ADRs)

Architecture not so easy

- Unfortunately, this is not an easy task, and the risks and costs associated with selecting an inappropriate technology are high
- Software architecture is the set of design decisions which, if made incorrectly, may cause your project to be cancelled

การออกแบบ architecture ง่ายจริงหรือ

Three Examples of Software Architecture

ระบบที่มี Functional req. เหมือนกัน
แต่มี Non-functional req. ต่างกัน

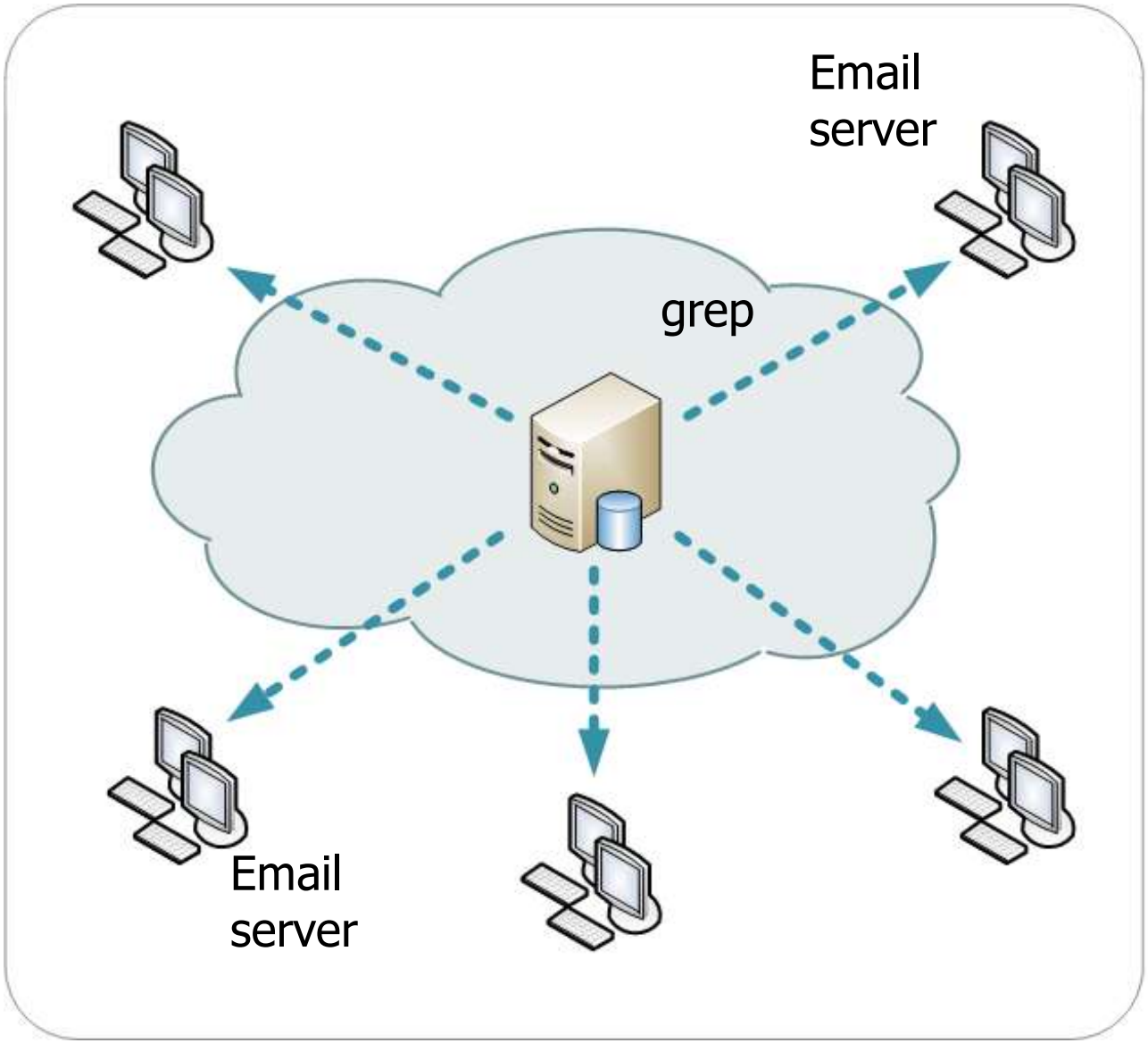
Simple Email Search App

- Many email servers with log files
- App search each email servers using grep query commands
- Need programmer to adjust the grep query
- Low cost and easy for initial use case
- If Huge number of servers → High overhead from sequentially searching

Version 1: Local log files

- **Version 1: Local log files.**
- The first version of the program was simple. There were already dozens of email servers generating log files.
- Rackspace wrote a script that would use ssh to connect to each machine and execute a grep query on the mail log file.
- Engineers could control the search results by adjusting the grep query.
- This version initially worked well, but over time the number of searches increased and the overhead of running those searches on the email servers became noticeable.
- Also, it required an engineer, rather than a support tech, to perform the search.

Sequential file of email logs



Centralized DB of Email Logs

- Active email log files are not accumulated
- History of email data are deleted
- Volume of log data is increasing
- Sequential searching becomes slower
- Easy searching UIs are needed

Version 2: Central Database

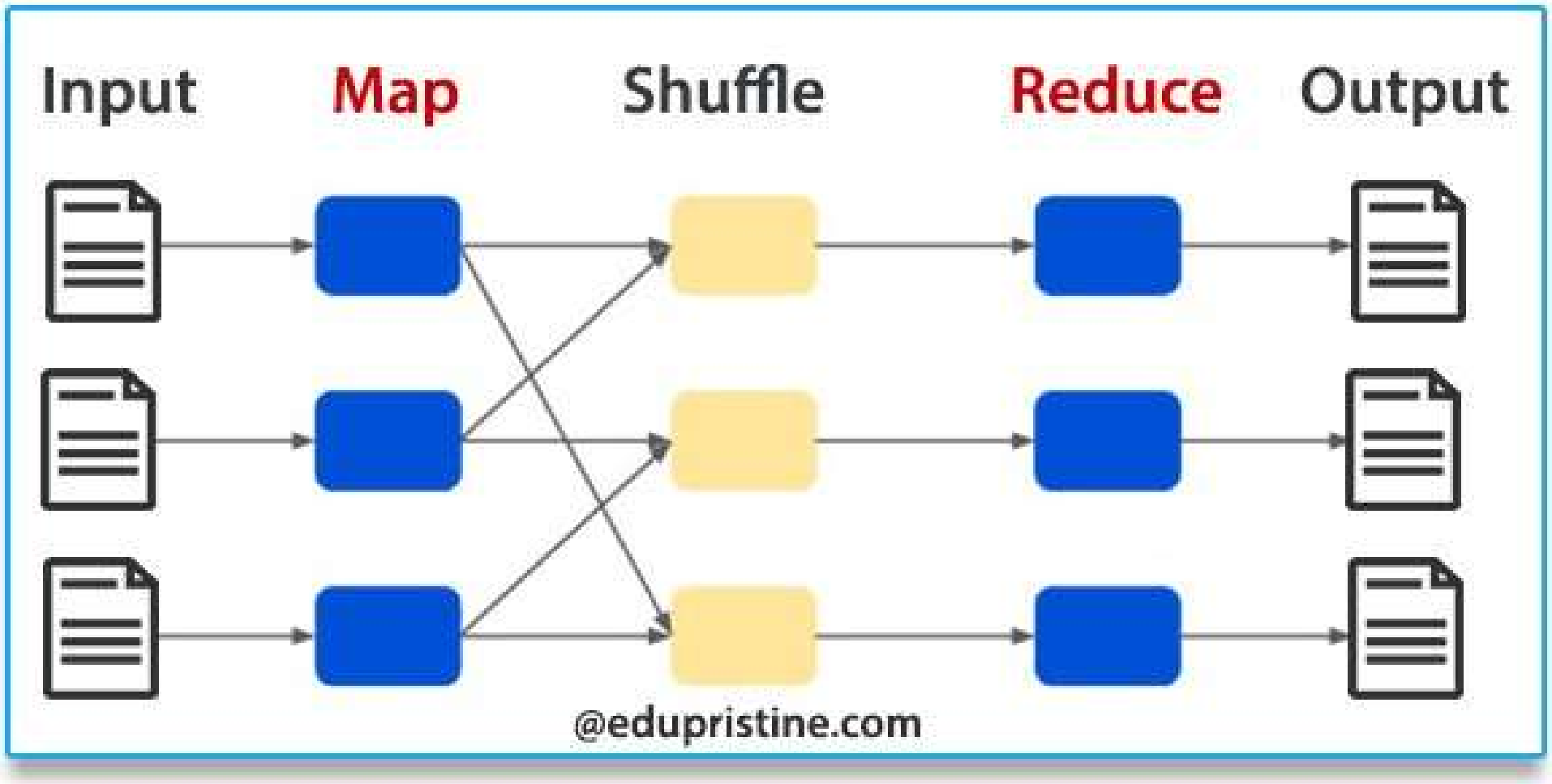
- The second version addressed the drawbacks of the first one by moving the log data off of the email servers and by making it searchable by support techs.
- Every few minutes, each email server would send its recent log data to a central machine where it was loaded into a relational database. Support techs had access to the database data via a web-based interface.
- Rackspace was now handling hundreds of email servers, so the volume of log data had increased correspondingly. Rackspace's challenge became how to get the log data into the database as quickly and efficiently as possible.
- The company settled on bulk record insertion into merge tables, which enabled loading of the data in two or three minutes. Only three days worth of logs were kept so that the database size would not hinder performance.
- Over time, this system also encountered problems. The database server was a single machine and, because of the constant loading of data and the query volume, it was pushed to its limit with heavy CPU and disk loads. Wildcard searches were prohibited because of the extra load they put on the server.
- As the amount of log data grew, searches became slower. The server experienced seemingly random failures that became increasingly frequent. Any log data that was dropped was gone forever because it was not backed up. These problems led to a loss of confidence in the system.

Centralized DB of email logs

Version 3: Indexing Cluster

- The third version addressed the drawbacks of the second by saving log data into a distributed file system and by parallelizing the indexing of log data. Instead of running on a single powerful machine, it used ten commodity machines.
- Log data from the email servers streamed into the Hadoop Distributed File System, which kept three copies of everything on different disks. In 2008, when Rackspace wrote a report on its experiences, it had over six terabytes of data spanning thirty disk drives, which represented six months of search indexes.
- Indexing was performed using Hadoop, which divides the input data, indexes (or “maps”) in jobs, then combines (or “reduces”) the partial results into a complete index.
- Jobs ran every ten minutes and took about five minutes to complete, so index results were about fifteen minutes stale. Rackspace was able to index over 140 gigabytes of log data per day and had executed over 150,000 jobs since starting the system.
- As in the second system, support techs had access via a web interface that was much like a web search-engine interface. Query results were provided within seconds.

Map-Reduce Server of Email logs



What if
Representing Architecture
using
Formal Model

Architectural Description Language (ADL)

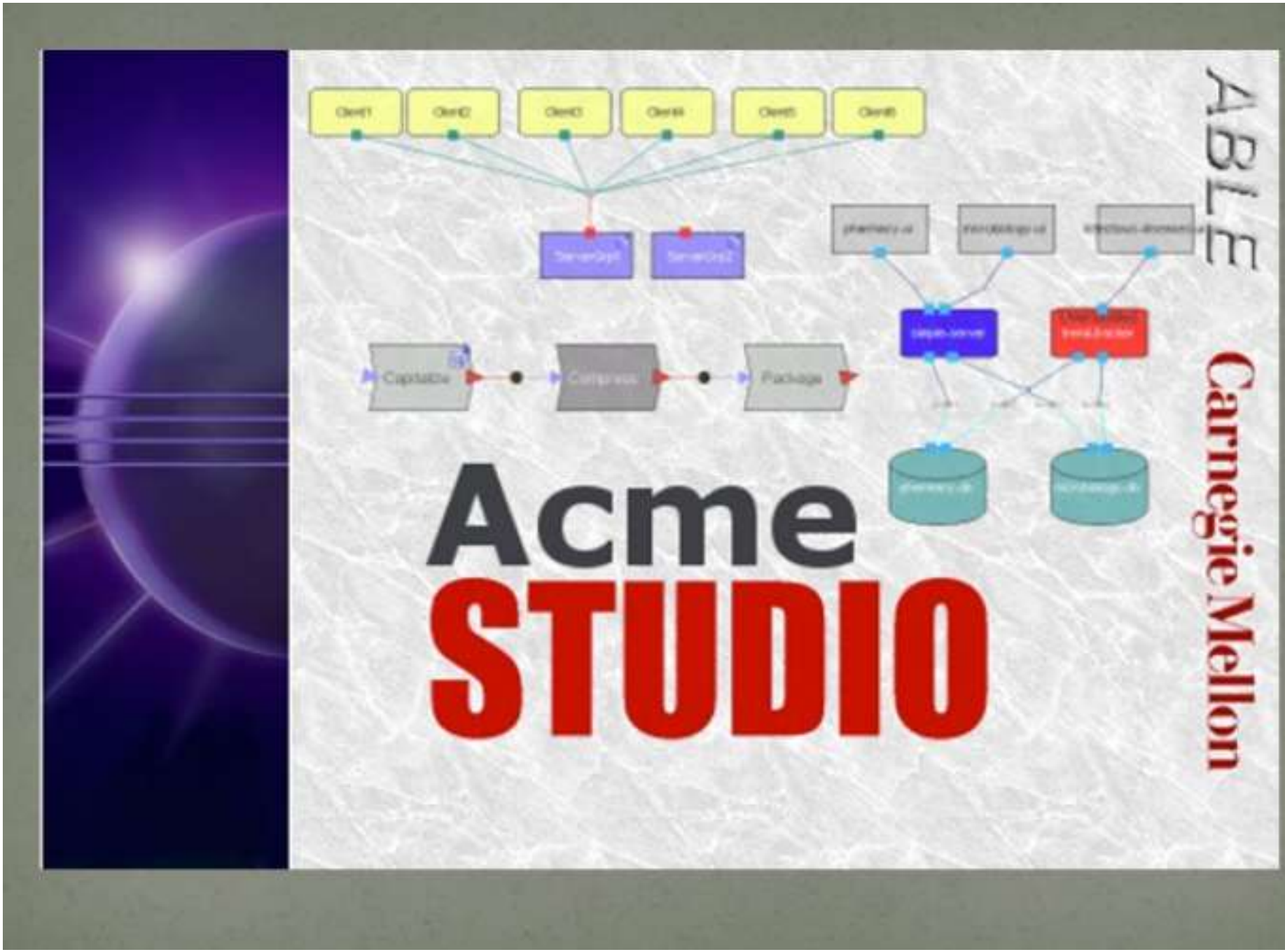
https://en.wikipedia.org/wiki/Software_architecture_description#cite_note-3

ADL

- An architecture description language (**ADL**) is any means of expression used to describe a software architecture (ISO/IEC/IEEE 42010).
- Many special-purpose ADLs have been developed since the 1990s, including
  - AADL (SAE standard),
  - Wright (developed by Carnegie Mellon),
  - Acme (developed by Carnegie Mellon),
  - xADL (developed by UCI),
  - Darwin (developed by Imperial College London),
  - ArchC
- UML is an alternative ADL

Acme – Carnegie Mellon University

- First version released in 1997
- Similar to IBM Rational for UML
- Two components:
  - Acme ADL
  - AcmeStudio
- Can act as a vehicle for standardizing elements used across multiple ADLs


ABLE
Carnegie Mellon
Acme
STUDIO

ArchC

- Specialized for processor architecture description.
- Allows users to generate assemblers and simulators for processors from:
  - Architecture Resources: User provides processor resource info from programmer's manual
  - Instruction Set Architecture: User enters information about each instruction such as format and syntax, behavior, and info for decoding
- Tailors the modeling environment to your processor

ArchC Example

```
AC_ARCH(mips){
  ac_mem    MEM:5M;
  ac_cache  l2cache("dm", 256, 32,  "lru", "wb", "wal");
  ac_icache icache("dm", 16, 4, "wt", "war");
  ac_dcache dcache("2w", 32, 4,  "lru", "wb", "wal");

  ac_regbank RB:34;
  ac_pipe    pipe = {IF, ID, EX, MEM, WB};
  ac_wordsize 32;

  ac_format IF_ID_Fmt = "%npc:32";
  ac_format ID_EX_Fmt = "%rd:5 %rs:32 %rt:32 %imm:32";

  ac_reg<IF_ID_Fmt> IF_ID;
  ac_reg<ID_EX_Fmt> ID_EX;
          ...
  ARCH_CTOR(mips){
    set_endian("big");

    icache.bindsTo( l2cache );
    dcache.bindsTo( l2cache );
    l2cache.bindsTo( MEM );
  }
};
```

Fig. 1. MIPS AC_ARCH resource declaration.

```
AC_ISA(mips){

 ac_format Type_R="%op1:6 %rs:5 %rt:5 %rd:5 0x00:5 %op2:6";

 ac_format Type_I="%op1:6 %rs:5 %rt:5 %imm:16";

 ac_instr<Type_R> add;
 ac_instr<Type_I> load;

 ISA_CTOR(mips){
   add.set_asm("add %reg,%reg,%reg," rd,rs,rt);
   add.set_decoder(op1=0x00, op2=0x20);

   load.set_asm("lw %reg,%imm(%reg)",rt,imm,rs);
   load.set_decoder(op1=0x23);

 };
};
```

Fig. 2. MIPS ISA Description.

UML Shortcomings as an ADL

- "[A]n ADL for software application focuses on the high-level structure of the overall application rather than the implementation details of any specific source module"

- Less formalized than ADLs
- No notion of entity restriction (styles)
- Largely a documenting language

ทำไมต้องมี Software Architecture

Architecture

WHY

- Architecture addresses non-functional requirements

Use case diagram บอก Non-functional req. ได้ไหม?
Class diagram บอกได้ไหม?

จงอธิบายความแตกต่างระหว่าง

Functional vs. Non-functional

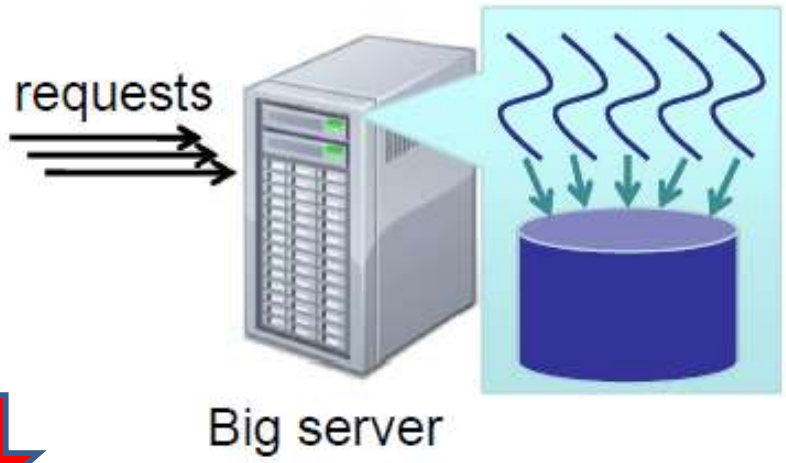
Non-functional มักจะมองไม่เห็นในการใช้งาน แรก ๆ แต่ปรากฏเมื่อเวลาผ่านไป ในการบำรุงรักษา

Martin fowler เรียกมันว่า Internal quality

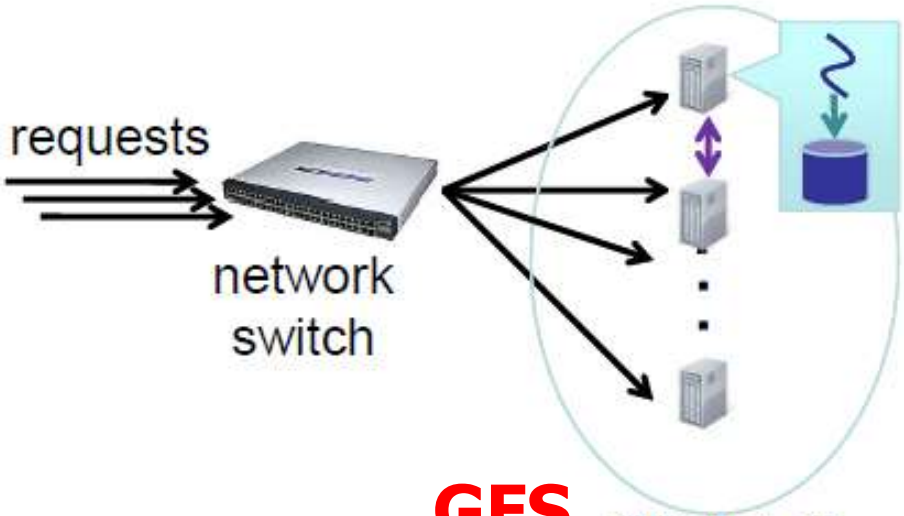
https://martinfowler.com/articles/is-quality-worth-cost.html

Two Architectures for Web Search

Altavista search engine



Google search engine



GFS

จงแจกแจงให้ความแตกต่าง

How does architecture affect system **properties**?

- Modifiability / ease of change
- Consistency of results
- System cost
- Scalability of system
- Reliability of system

ทั้งสองระบบนี้ทำ **function** ได้เท่ากันแต่

Function = web search

Non-funct. = …

WHY

Quality Factors
(some non-functional reqs.)

Quality Factors

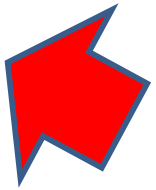
Most of a software architect's work is focused on designing software systems to meet a set of quality factor requirements.

General software quality factors

- Scalability
- Security
- Performance
- Modifiability
- Availability
- Integration

Quality ที่พบบ่อยบางส่วนเท่านั้น

Design Trade-offs



- Quality factors บางคู่ไม่แปรตามกัน
- For example, a **highly secure** system may be difficult or **impossible to integrate** in an open environment.
- A **highly available** application may trade-off **lower performance** for greater availability.
- An application that requires **high performance** may be tied to a particular platform, and hence **not be easily portable**

เลือก quality factors อย่างเหมาะสม

When is architecture important?

- Small solution space
  - เช่น making a faster car is often no harder than adding a bigger engine
- High failure risk
  - เช่น People might die if your hospital system fails
- Difficult quality attributes
  - เช่น making email with quick performance that supports millions of users is hard
- New domain
- Product lines
  - เช่น Some sets of products share a common architecture

A Risk Analysis in SW ARCH

- **FMEA** (Failure Modes and Effects Analysis) is a **structured method** used to **identify, analyze, and prioritize potential failures** in a process, system, or product — including **software architecture** and **Agile/Scrum projects** — based on their impact, likelihood, and detectability.
- The approach was developed by the United States Military in the late 1940s.

FMEA Risk Model

- What could go wrong? (Failure Mode)
- Why would it happen? (Cause)
- What would happen if it did? (Effect)
- How likely is it, how severe, and how easy to detect?

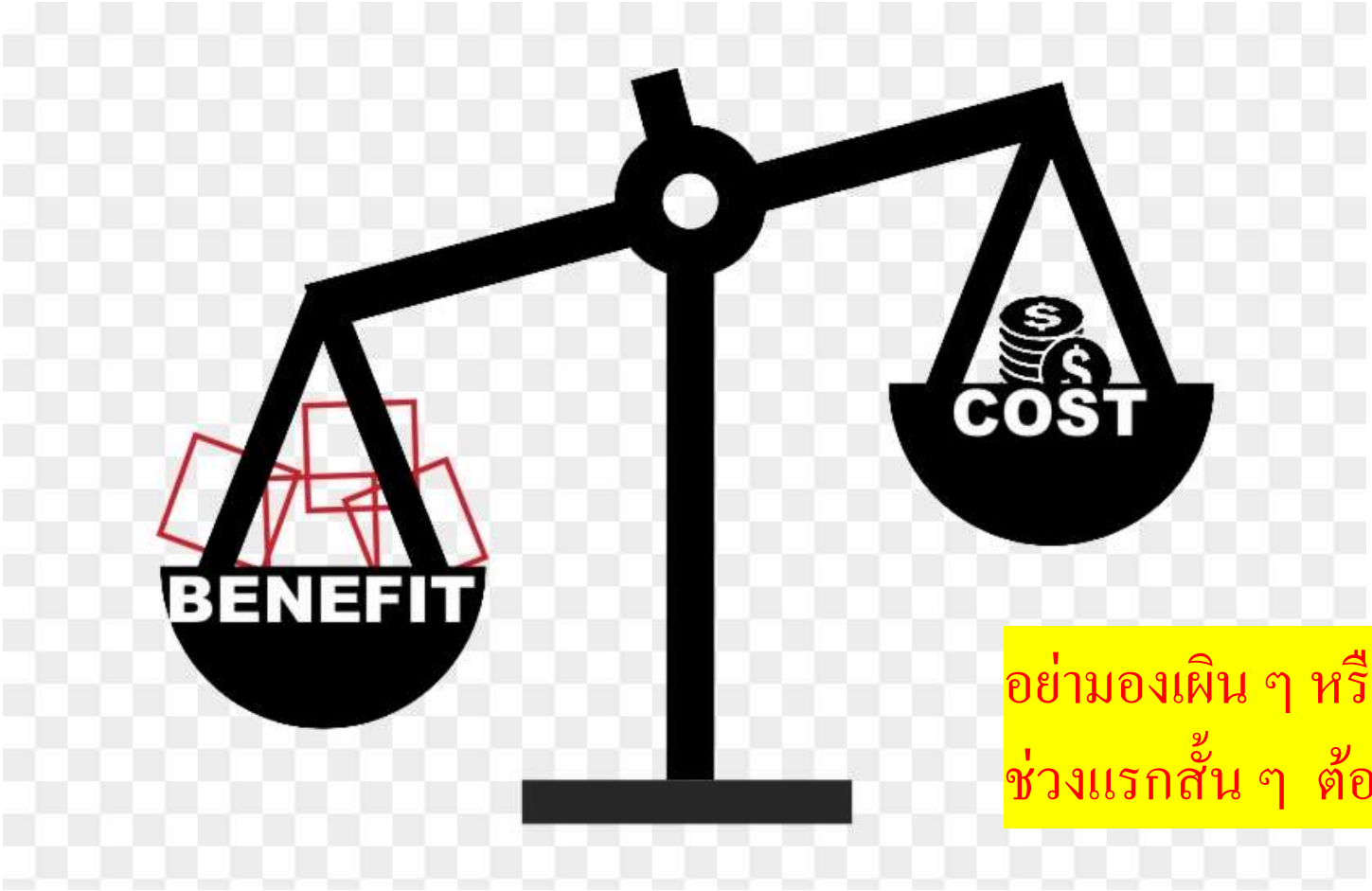
Key Components of FMEA

Term	Meaning	Scale (typical)
Failure Mode	The way something could fail	—
Effect	Consequences of the failure	—
Cause	Why the failure might occur	—
Severity (S)	How severe the effect is (to the user/system)	1 (low) to 10 (critical)
Occurrence (O)	Likelihood of the cause/failure happening	1 (rare) to 10 (frequent)
Detection (D)	Likelihood of detecting it before failure	1 (certain) to 10 (undetected)
RPN (Risk Priority Number)	RPN = S × O × D	1 to 1000

Example of SW ARCH FMEA

Failure Mode	Effect	Cause	S	O	D	RPN
Microservices fail to scale	Poor performance under load	Inadequate load testing	8	6	7	336
Database becomes bottleneck	System slowdown	Poor indexing, no caching	7	5	6	210
Insecure API exposed	Data breach	No authentication	9	4	8	288
Code module crashes	Service interruption	Uncaught exceptions	6	5	4	120

Cost Benefit Analysis for SW Arch



อย่ามองเผิน ๆ หรือมองแค่ช่วงแรกสั้น ๆ ต้องมองยาว ๆ

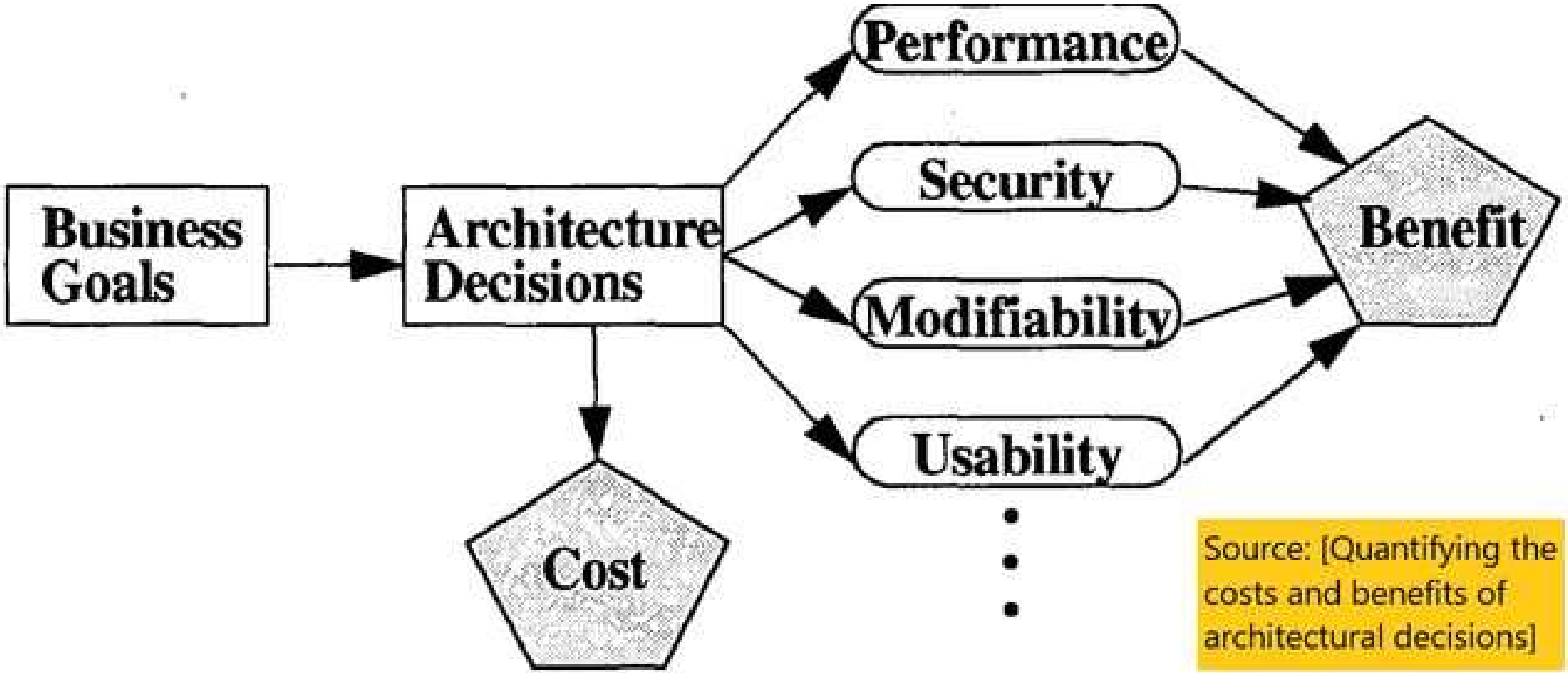
Organizations tend to consider costs only in terms of building a system, and they fail to consider the costs associated with maintaining and upgrading it.

CBAM from SEI

- Cost Benefit Analysis Method (CBAM)
- CBAM process consists of the following steps
  1. Choose scenarios and architectural strategies
  2. Assess quality attribute benefits
  3. Quantify the benefits of architectural strategies
  4. Quantify the costs and schedule implications of the architectural strategies
  5. Calculate the desirability of each option
  6. Make architectural design decisions.

https://resources.sei.cmu.edu/asset_files/FactSheet/2018_010_001_513478.pdf

The Context of CBAM



เราออกแบบ Arch ตามใจชอบได้ไหม?

ดีไหม ถ้ามีใครมาแนะนำวิธีการออกแบบ ไม่ต้องเริ่มจากศูนย์?

Architectural Styles

- Architectural styles are high-level design
- GoF's design patterns are low-level design 

What is a Software Architectural Style?

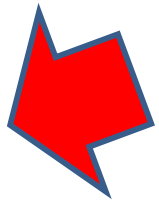
- Architectural Style =
  Components + Connectors + Constraints
- Primarily,
  - Components: computational elements
  - Connectors: interactions between components
  - Constraints: how components and connectors may be combined

Questions About Architectural Styles

- What is the design vocabulary?
- What are the allowable patterns?
- What is the underlying computational model?
- What are the essential invariants?
- What are common examples?
- What are advantages and disadvantages?
- What are common specializations?

Examples of Architectural Styles

- Call and return
- Data Abstraction
- Implicit Invocation (Call back)
- Layered
- Pipe and Filter
- Repository (Blackboard or Hub&Spokes)
- Tiers (3-tiers)
- Model-View-Controller
- Service Oriented Architecture (SOA)
- Web Services
- Microservices
- Etc.



5W2H method

Type	5W2H	Description	Countermeasure
Subject Matter	What?	What is being done? Can this task be eliminated?	Eliminate unnecessary tasks
Purpose	Why?	Why is this task necessary? Clarify the purpose.	
Location	Where?	Where is it being done? Does it have to be done there?	Change the sequence or combination
Sequence	When?	When is the best time to do it? Does it have to be done then?	
People	Who?	Who is doing it? Should someone else do it? Why am I doing it?	
Method	How?	How is it being done? Is this the best method? Is there some other way?	Simplify the task
Cost	How much?	How much does it cost now? What will the cost be after improvement?	Select an improvement method

Software Architecture

- What – Definition
- Why – Quality factors (non-functional req.)
- When – High level design
- Where – Dev Office
- Who – SW Architect
- How – Document to communicate (model, styles)
- How many – Cost

คำสำคัญ

- Software Architecture
- Model, Level of Abstraction
- Architectural Views
- Architectural Viewpoints
- Architectural Styles (Patterns)
- Architectural Representation/Documentation
- Architectural Decision Record (ADR)

สิ่งเหล่านี้กำหนดว่าเราจะต้อง model อย่างไร

- Constraints
- Risks
- Non-functional requirements
- เช่น นำระบบ Online shopping ที่เรียนได้มา และเพิ่มเงื่อนไขเหล่านี้
  - Scalability
  - Security
  - Cost constraints
  - Connecting to the Legacy systems
  - 247 Availability
  - …

UML for Software Architecture

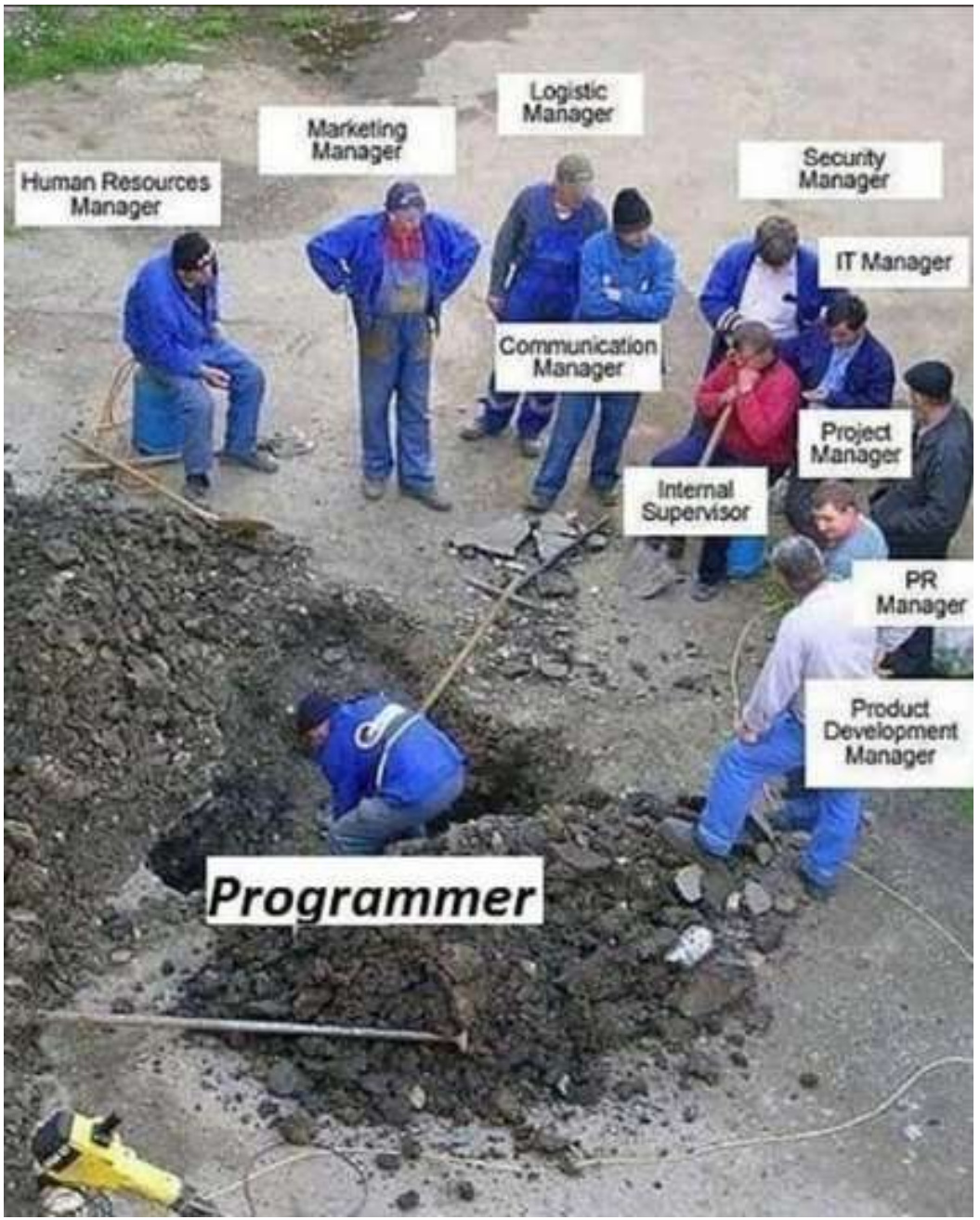
- Subsystem diagram
  - Subsystem Interface (provided, required) also called “ball and socket interface”
- Component diagram
- High level sequence diagram
- Deployment diagram

Roles in Software Development Project

- CEO
- CIO
- Project Champion
- Project Manager
- Business Analyst
- Designer
- Programmer
- Tester
- QA Officers

…..?? Software Architect ??

… อยู่ไหน



การบ้าน

- List 50 Keywords พร้อมอธิบายสั้นๆ ส่งบน MCV