



**Software Engineering
in der industriellen Praxis
(SEIP)**

Dr. Ralf S. Engelschall

Declarative Languages

Express the **target state**
and let the machine figure out the steps.

<h4>Markup Languages</h4> <p>Write text intermixed with markup information.</p> <pre>foo bar baz quux</pre> <p>Examples: Wiki, Markdown, AsciiDoc, SGML, HTML, TeX, R(un)off, reStructuredText, RTF</p>	<h4>Configuration Languages</h4> <p>Express complex textual configurations.</p> <pre>foo bar quux { baz; quux id 7; baz }</pre> <p>Examples: INI, XML, SXML, JSON, YAML, TOML, HCL</p>
<h4>Rule Languages</h4> <p>Express logic and semantics through complex rules.</p> <pre>foo(x, y) <- bar(x, y, z) AND x < 42 AND z >= 10</pre> <p>Examples: SQRL, Datalog/RuleML, OWL/SWRL, RIF</p>	<h4>Constraint Languages</h4> <p>Find solutions for complex constraints.</p> <pre>foo @ bar(X, Y), baz(X, Y, _) => quux.</pre> <p>Examples: MiniZinc, CHR, OCL, Rego, Z3.</p>
<h4>Query Languages</h4> <p>Retrieve information through paths and expressions.</p> <pre>// foo / bar [@baz == "xxx" && @quux > 10]</pre> <p>Examples: Glob, RegExp, CSS Selector, XPath, YARA, GraphQL, SQL, SPARQL, Cypher, GQL, ASTq</p>	<h4>Validation Languages</h4> <p>Parse and validate complex textual information.</p> <pre>foo ::= "bar(#) (? [0-9a-fA-F]{2})+ "</pre> <p>Examples: RegExp, Ducky, BNF, PEG, RELAX NG</p>

solution approach: automatically, non-obvious
execution control: automatically, pre-defined
performance optimization: automatically, pre-defined

Imperative Languages

Express the **steps**
how the machine has to reach the target state.

<h4>Shell Languages</h4> <p>Automate execution of system commands.</p> <pre>foo -x 2>&1 bar -y --quux <(cat *,cf)</pre> <p>Examples: Korn-Shell, Bourne-Shell, Bash, C-Shell, Batch-Script, PowerShell, AppleScript, DCL</p>	<h4>Programming Languages</h4> <p>Execute complex algorithmic steps.</p> <pre>for (let i = 0; i < 10; i++) foo(i, 42)</pre> <p>Examples: JavaScript, TypeScript, Scala, Kotlin, Java, C#, C/C++, Rust, Go, Python, Perl, Ruby, Lua</p>
<h4>Text-Processing Languages</h4> <p>Manipulate texts through transformations.</p> <pre>/^foo/,/bar.*baz/ s/quux\([0-9]*\)/foo\1/g</pre> <p>Examples: ed, ex, sed, AWK, TXR, XSLT, JSLT</p>	<h4>Macro Languages</h4> <p>Pre-process texts with macros.</p> <pre>define('foo', `bar\$1baz`) foo(quux)bar</pre> <p>Examples: m4, GPP, CPP, Zoem, ProMac</p>
<h4>Expression Languages</h4> <p>Expand path, arithmetic, and boolean expressions.</p> <pre>{{ foo,bar[*],baz[42] ,quux + 1 }}</pre> <p>Examples: JQ, YQ, MozJEXL, MathML, JUEL, SPeL</p>	<h4>Template Languages</h4> <p>Expand complex text fragments.</p> <pre>{% for k, v in items %} {{k}}: {{v}}{% endfor %}</pre> <p>Examples: Pug, Nunjucks, Handlebars, Mustache, Jinja, Jsonnet</p>

solution approach: manually, obvious
execution control: manually, fine-grained
performance optimization: manually, fine-grained

Examples: essential recommended alternative

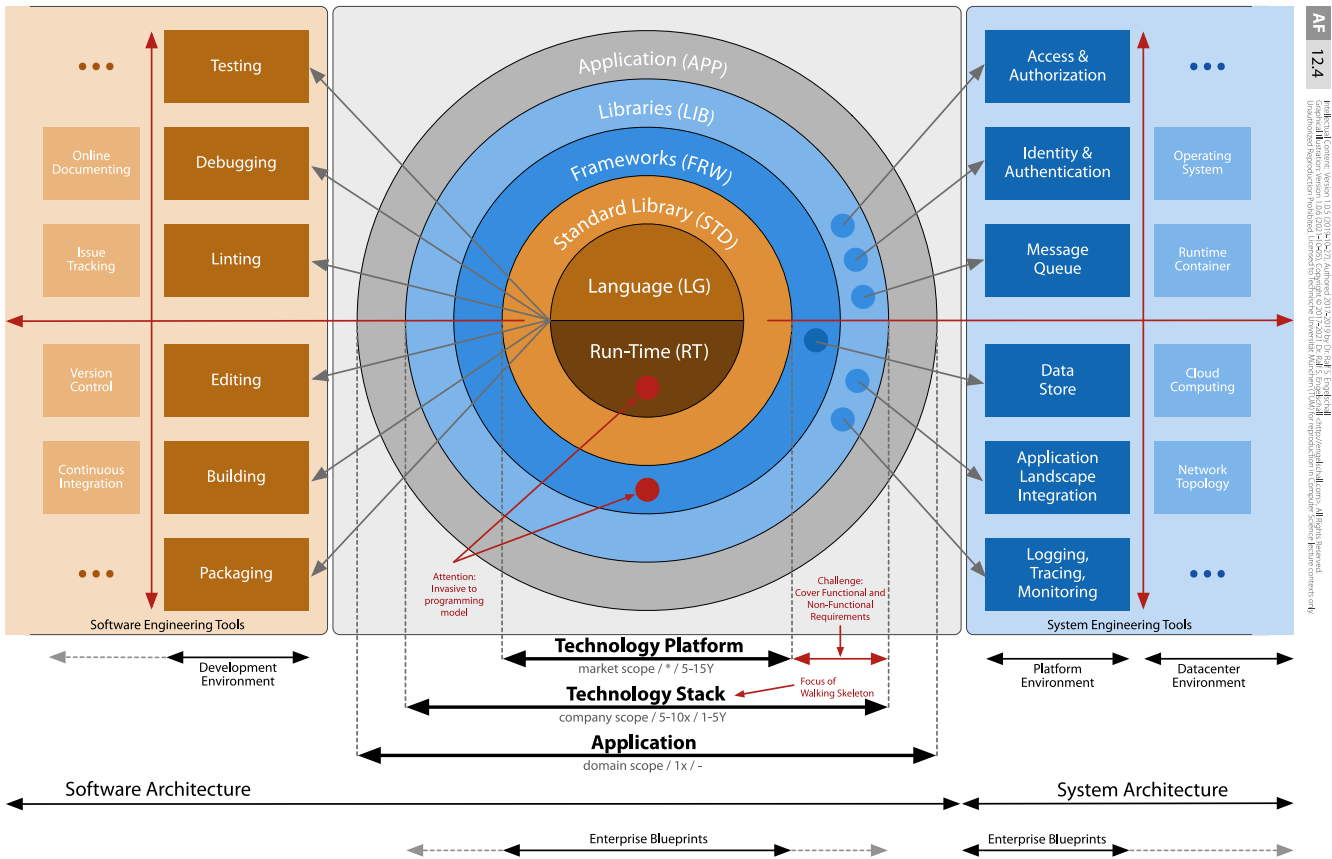
There are innumerable **Formal Languages**. In a technology stack, usually, almost a dozen such languages are used at the same time. The architect must therefore select them very carefully.

The formal languages can first be divided into **Declarative Languages** and **Imperative Languages**. The former expresses a target state ("WHAT"), the latter expresses the way to get there ("HOW").

Declarative approaches are usually to be preferred to imperative approaches because they leave it to the implementation (and not to the programmer) to find the optimal way. In addition, they permit incremental approaches, where the next step is determined by the particular difference between the current state and the desired target state. This is especially important for recovery in very dynamic and error-prone environments.

Questions

❓ Into which two classes can **Formal Languages** be divided?



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A **Technology Platform** consists of a **Language**, an optional **Run-Time** environment and a **Standard Library**. On top of this, **Frameworks** and **Libraries** extend this to a **Technology Stack**, in which with them especially all the prerequisites for the functional and non-functional requirements in the **Application** are achieved.

It has to be noted that the **Run-Time** and the **Frameworks** are usually extremely “invasive” to the programming model and thus can almost never be replaced afterwards. Therefore, with the so-called **Walking Skeleton**, the focus is mainly on the **Technology Stack** to be defined and integrated.

While the **Application** has a functional scope and is implemented only once, a particular **Technology Stack** is usually defined by a company and then reused several times over a period of a few years.

The underlying particular **Technology Platform**, on the other hand, is implemented by a third party for the market, is reused as often as required and must exist for quite a long period of time.

Large companies, therefore, usually stringently define the **Technology Platforms** and **Technology Stacks** in their **Enterprise Blueprints**.

For the **Software Engineering Tools** one should take into account the tools for **Testing**, **Debugging**, **Linting**, **Editing**, **Building** and **Packaging** of the **Development Environment**, because these are usually directly dependent on the particular **Technology Stack**.

The situation is similar for the **System Engineering Tools** of the **Platform Environment**: these require at least the associated **Libraries** in the **Technology Stack**, in order to be addressed during the run-time of the **Application**.

Questions

- ❓ What are the three components of a **Technology Platform**?
- ❓ Which two additional components make up a **Technology Stack**, compared to the **Technology Platform**?
- ❓ Which two components of a **Technology Stack** are most “invasive” to the programming model?

<p>ED Environment Detection</p> <p>Detect the run-time environment, like underlying operating system, execution platform, network topology, feature toggles, etc.</p> <p>Node process, syspath</p> 	<p>SN Server Networking</p> <p>Listen to network sockets, accept connections and manage request/response and message communication.</p> <p>HAPI hapi-plugin-websocket, ws</p> 	<p>CN Client Networking</p> <p>Provide mechanisms to connect to peers over the network and perform request/response and/or publish/subscribe communication.</p> <p>(none) Axios, MQTT.js, ws</p> 
<p>AP Argument Parsing</p> <p>Parse options and arguments of the Command-Line Interface (CLI) to bootstrap application parameters.</p> <p>(none) yargs</p> 	<p>PI Peer Information</p> <p>Determine unique identification and add-on information about the client peer.</p> <p>HAPI hapi-plugin-peer, geoip</p> 	<p>TS Task Scheduling</p> <p>Schedule and execute recurring tasks independent of regular I/O operations.</p> <p>(none) node-scheduler</p> 
<p>CP Configuration Parsing</p> <p>Load and parse directives from configuration file to bootstrap application parameters.</p> <p>(none) js-YAML</p> 	<p>SH Session Handling</p> <p>Manage secured per-connection sessions to keep state between communication requests and/or client sessions.</p> <p>HAPI YAR</p> 	<p>ET Execution Tracing</p> <p>Provide mechanisms for tracing the execution by logging event and measurement information at certain points of interest.</p> <p>Microkernel Winston</p> 
<p>PD Process Daemonizing</p> <p>Detach from the startup terminal and host process in order to run fully independently.</p> <p>(none) daemonize2</p> 	<p>UA User Authentication</p> <p>Determine and validate the unique identity of the user communicating over the current network connection.</p> <p>HAPI JWT, Passport</p> 	<p>DA Database Access</p> <p>Map in-memory domain entities onto data store dependent persistent data structure.</p> <p>Sequelize GraphQL-Tools-Sequelize</p> 
<p>PM Process Management</p> <p>(Pre-)fork child processes and/or threads of execution and monitor and control them during the life-cycle of the application.</p> <p>(none) cluster, nodemon</p> 	<p>RV Request Validation</p> <p>Validate the syntactical and semantical compliance of the requests and sanitize the requests.</p> <p>HAPI Joi, DuckyJS</p> 	<p>DC Database Connectivity</p> <p>Locally or remotely connect the database access layer to the underlying data store.</p> <p>Sequelize sqlite3, pg</p> 
<p>CM Component Management</p> <p>Structure the code into components, instantiate them under run-time and manage them in a stateful component life-cycle.</p> <p>Microkernel (none)</p> 	<p>RP Request Processing</p> <p>Process the request by dispatching execution according to the provided request and determined context information.</p> <p>HAPI GraphQL.js</p> 	<p>DS Database Schema</p> <p>Create, update or downgrade the data schema inside the underlying data store.</p> <p>Sequelize (none)</p> 
<p>CC Component Communication</p> <p>Provide inter-component communication mechanisms like events, hooks, registry, etc.</p> <p>Microkernel Latching</p> 	<p>RA Role Authorization</p> <p>Determine whether the role of the current user is allowed to execute the current request.</p> <p>(none) GraphQL-Tools-Sequelize</p> 	<p>DB Database Bootstrapping</p> <p>Create, update or downgrade both mandatory bootstrapping and optional domain-specific data inside the underlying data store.</p> <p>Sequelize ini</p> 

To define a Technology Stack for a **(Thin-)Server**, 21 **Aspects** have to be considered. Each Aspect is covered by at least one **Framework** or **Library**. In practice, each Aspect is usually covered by one Framework and zero or more Libraries. The goal always is: to achieve the greatest possible coverage of the Aspects with a minimum number of Frameworks and Libraries.

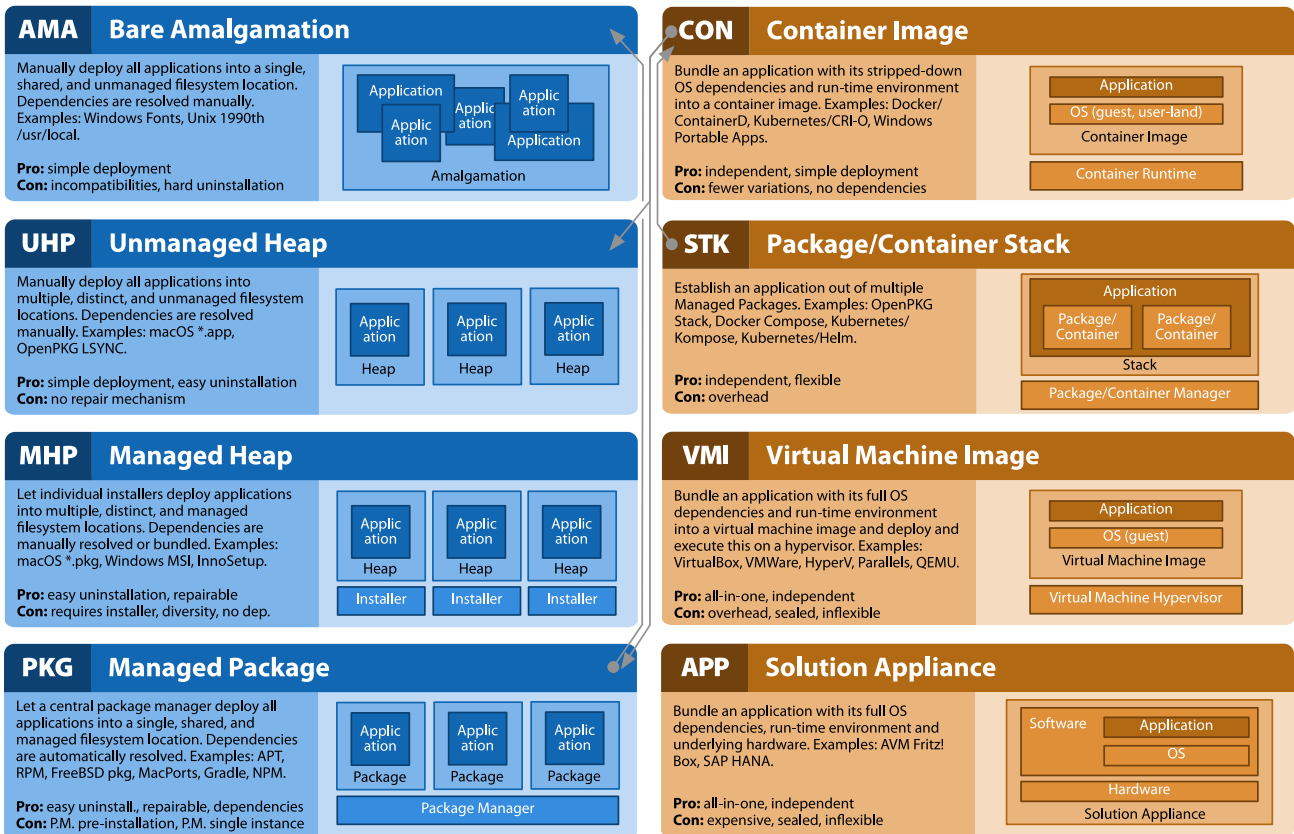
It is advisable to use Open Source Software (OSS) for both Frameworks and Libraries and, if possible, to no own custom implementations, as the effort usually is not in proportion to the benefit. Because all Aspects are technical — and not functional — Aspects of a user interface.

It is to be noted that a server usually does not only have the Aspect **Server Networking** (for the connection of the Rich Clients), but also the Aspect **Client Networking**, in order to be able to query other servers.

In addition, it is to be noted that, above all, two important Aspects address security issues: the Aspect **User Authentication** identifies and authenticates the user (“Is the user the one?”). The Aspect **Role Authorization**, on the other hand, before all business processes, checks whether the authenticated user really is authorized to initiate the processes due to his role(s) (“Is the user allowed to do this?”).

Questions

- ❓ Why does a **(Thin-)Server** usually have, besides the obvious aspect **Server Networking**, also the aspect **Client Networking**?
- ❓ Which Aspect of a **(Thin-)Server** takes care of the Question “Is the user the one”?
- ❓ Which aspect of a **(Thin-)Server** takes care of the question “Is the user allowed to do this”?



During **Software Deployment**, an **Application** is installed on a file system for execution. With the **Bare Amalgamation**, the files are copied into a central directory (e.g., Windows C : \Windows\system32). This is easy to realize but makes the clean removal later on very hard.

With **Unmanaged Heap**, each application is copied into a separate directory (e.g., macOS *.app). This is very easy to realize and also allows easy removal. But one still has no repair possibilities. With **Managed Heap**, an own installer is required for each application, among other things, to get repair possibilities (e.g., Windows MSI).

With **Managed Package**, a central Package Manager is used, which standardizes the administration (e.g., DPKG/APT or RPM). It also allows the resolving of dependencies. If, on the other hand, one wants to make the application more independent of the operating system and install it as a shielded unit, the **Container Image** deployment offers itself (e.g., Docker). This is where the application is bundled together with all its dependencies and a part of the operating system.

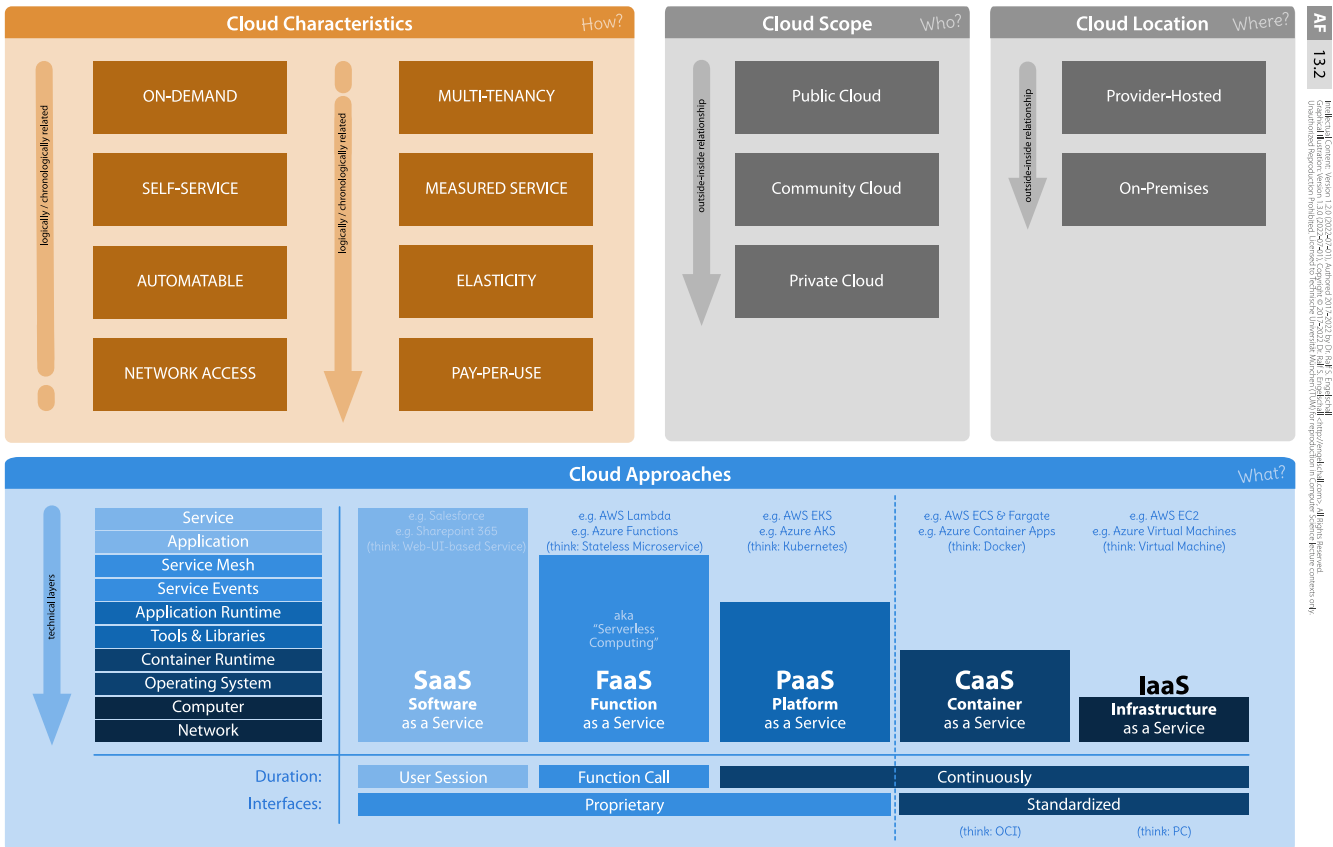
To be more flexible, one can keep the **Managed Packages** or **Container Images** very small and instead define an application through an entire **Package/Container Stack** (e.g., Docker Compose).

If one needs more shielding, a **Virtual Machine Image** offers itself. Here the application is bundled with all its dependencies and the complete operating system and is installed on a virtual machine (e.g. ORACLE VirtualBox). As the maximum expansion level, the application can be installed as a **Solution Appliance**, where the application, its dependencies, the associated operating system, and the underlying hardware are bundled into one total solution (e.g., SAP HANA).

In practice, the various approaches occur mainly in combined form. A **Container Stack** consists of **Container Images**. These, in turn, are built by installing dependencies via **Managed Packages**, and the application itself as an **Unmanaged Heap**, into the container. The **Managed Packages**, beforehand during packaging, are created with **Bare Amalgamation** steps.

Questions

- Which type of **Software Deployment** bundles and installs an application with all its dependencies and part of the operating system?



Cloud Computing has four essential dimensions. The first dimension **Cloud Characteristics** ("How?") describes the eight characteristics of how a resource provisioning must happen in order for the provisioning to be considered as **Cloud Computing**: **On-Demand**, **Self-Service**, **Automatable**, **Network-Access**, **Multi-Tenancy**, **Measured Service**, **Elasticity** (aka Scalability), and **Per-Per-Use**.

With these characteristics, in the second dimension, there are various **Cloud Approaches** ("What?"), which specify what is provided: for **Infrastructure as a Service (IaaS)**, only **Network** and a **Computer** is provided, usually a virtual machine. With **Container as a Service (CaaS)** additionally a (Host) **Operating System** and a **Container Run-Time** are provided.

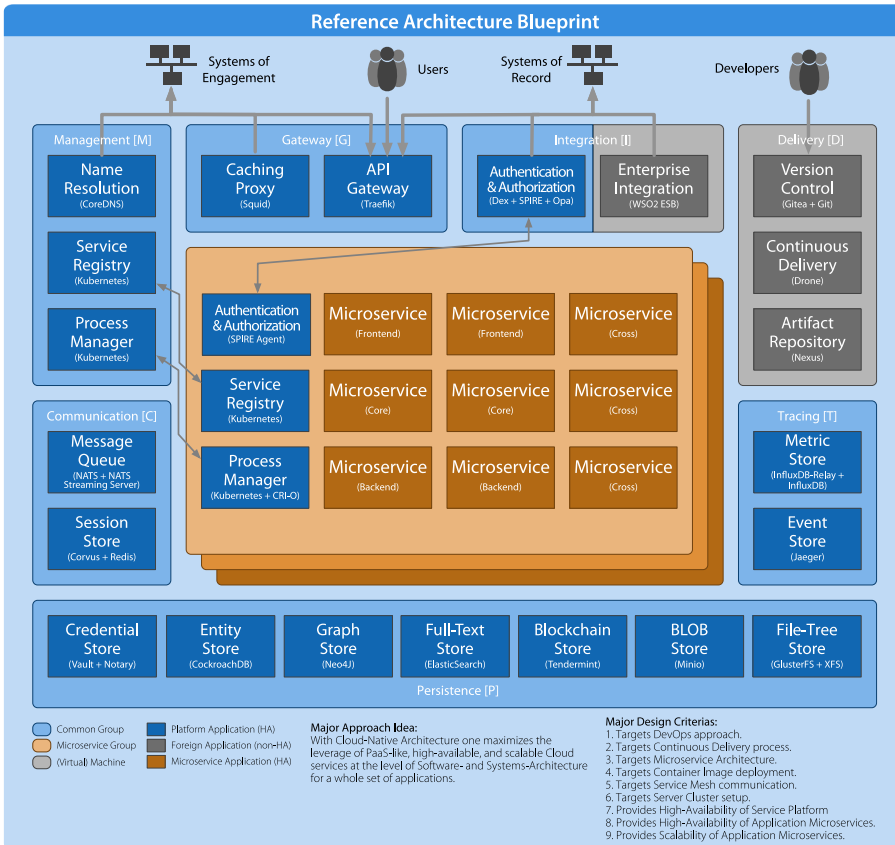
For **Platform as a Service (PaaS)**, additional surrounding **Tools & Libraries** and an **Application Run-Time** are provided; with **Function as a Service (FaaS)** additionally external **Service Events** and a **Service Mesh** and for **Software as a Service (SaaS)** the **Application** and the its (functional) **Service** are additionally provided.

The third dimension **Cloud Scope** ("Who?"), states for whom the resources are provided: **Public Cloud** for public Cloud Computing, **Community Cloud** for Cloud Computing of a closed group of organizations, and **Private Cloud** for Cloud Computing of a single organization.

Finally, the fourth dimension **Cloud Location** ("Where?"), states where the resources are physically provided: **Provider-Hosted** means at an external provider, **On-Premises** means locally at the using organization.

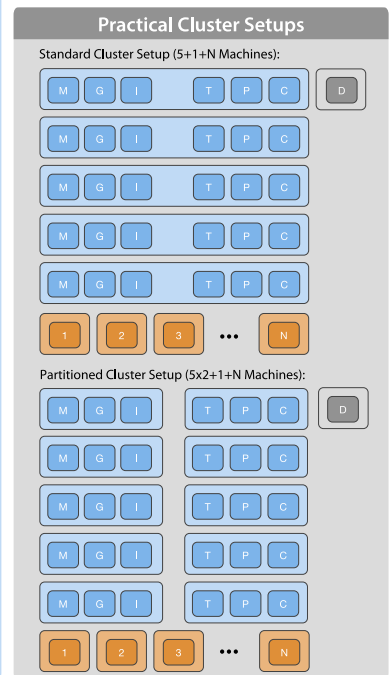
Questions

- ❓ List at least 5 of the 8 **Cloud Characteristics** that a resource provisioning must fulfill for it to be considered **Cloud Computing**!
- ❓ In which **Cloud Approach** is only **Network** and **Computer** provided?



CNCF Cloud-Native Definition 1.0

Cloud-native technologies empower organizations to build and run scalable applications in modern, dynamic environments such as public, private, and hybrid clouds. Containers, service meshes, microservices, immutable infrastructure, and declarative APIs exemplify this approach. These techniques enable loosely coupled systems that are resilient, manageable, and observable. Combined with robust automation, they allow engineers to make high-impact changes frequently and predictably with minimal toil.



In **Cloud-Native Architecture**, applications are developed, installed and operated in such a way that the advantages of **Cloud Computing** are maximized and, in particular, that all infrastructure services are provided by a central **Service Platform**.

In practice, this ideally means the combination of an agile **DevOps** approach, an end-to-end **Continuous Delivery** process, a flexible **Microservice** software architecture, the use of a stable **Container Image** based software deployment, the use of a **Service Mesh** for internal Microservice communication, and the use of a **Server Cluster** for scaling the Microservices.

The **Service Platform** is divided into the 7 service areas **Management, Gateway, Integration, Tracing, Persistence, Communication** plus **Delivery**, which are usually partitioned in a failsafe 5+1 or alternatively in a partially partitioned form on 5x2+1 machines. The Microservices of the application are installed on the **Service Platform** on separate machines.

In a **Cloud-Native Architecture**, it comes down to achieving **High Availability** and **Scalability** for both the services of the platform as well as for the Microservices of the application.

Questions

- 1. On which two essential aspects is the **Cloud-Native Architecture** based?
- 2. What does the **Cloud-Native Architecture** offer to the **Microservices** of an application?

