



# **Software Engineering in Industrial Practice (SEIP)**

Dr. Ralf S. Engelschall

## Declarative Languages

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

### Markup Languages

Write text intermixed with  
markup information.



```
foo <em>bar <strong>baz  
</strong></em> quux
```

Examples:  
Wiki, **Markdown**, AsciiDoc, SGML, **HTML**,  
TeX, R(un)off, reStructuredText, RTF

### Configuration Languages

Express complex textual  
configurations.



```
foo bar quux { baz;  
quux id 7; baz }
```

Examples:  
INI, XML, SXML, JSON,  
**YAML**, TOML, HCL

### Rule Languages

Express logic and semantic  
through complex rules.



```
foo(x, y) <- bar(x, y, z)  
AND x < 42 AND z >= 10
```

Examples:  
SQRL, Datalog/RuleML,  
OWL/SWRL, RIF

### Constraint Languages

Find solutions for  
complex constraints.



```
foo @ bar(X, Y),  
baz(X, Y, _) ==> quux.
```

Examples:  
MiniZinc, CHR,  
OCL, Rego, Z3.

### Query Languages

Retrieve information through  
paths and expressions.



```
// foo / bar [ @baz ==  
"xxx" && @quux > 10 ]
```

Examples:  
Glob, **RegExp**, **CSS Selector**, XPath, YARA,  
GraphQL, SQL, SPARQL, Cypher, GQL, ASTq

### Validation Languages

Parse and validate complex  
textual information.



```
foo ::= "bar(#" (?)  
[0-9a-fA-F]{2})+ "
```

Examples:  
**RegExp**, Ducky, BNF,  
**PEG**, RELAX NG

solution approach:  
execution control:  
performance optimization:

automatically, non-obvious  
automatically, pre-defined  
automatically, pre-defined

## Imperative Languages

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

### Shell Languages

Automate execution of  
system commands.



```
foo -x 2>&1 | bar -y  
--quux <(cat *,cf)
```

Examples:  
Korn-Shell, Bourne-Shell, **Bash**, C-Shell,  
Batch-Script, **PowerShell**, AppleScript, DCL

### Text-Processing Languages

Manipulate texts through  
transformations.



```
/^foo/,/bar.*baz/  
s/quux\([0-9]*\)/foo\1/g
```

Examples:  
ed, ex, **sed**, AWK,  
TXR, XSLT, JSLT

### Expression Languages

Expand path, arithmetic, and  
boolean expressions.



```
{{ foo,bar[*],baz[42]  
 ,quux + 1 }}
```

Examples:  
**JQ**, **YQ**, MozJEXL, MathML,  
JUEL, SpEL

### Programming Languages

Execute complex  
algorithmic steps.



```
for (let i = 0; i < 10;  
i++) foo(i, 42)
```

Examples:  
**JavaScript**, **TypeScript**, **Scala**, **Kotlin**, Java,  
C#, C/C++, **Rust**, **Go**, Python, Perl, Ruby, Lua

### Macro Languages

Pre-process texts with  
macros.



```
define('foo', `bar$1baz`)  
foo(quux)bar
```

Examples:  
**m4**, GPP, CPP,  
**Zeom**, ProMac

### Template Languages

Expand complex  
text fragments.



```
{% for k, v in items %}  
{k}: {v}}{% endfor %}
```

Examples:  
Pug, **Nunjucks**, Handlebars,  
Mustache, Jinja, **Jsonnet**

solution approach:  
execution control:  
performance optimization:

manually, obvious  
manually, fine-grained  
manually, fine-grained

Examples:  
**essential**  
recommended  
alternative

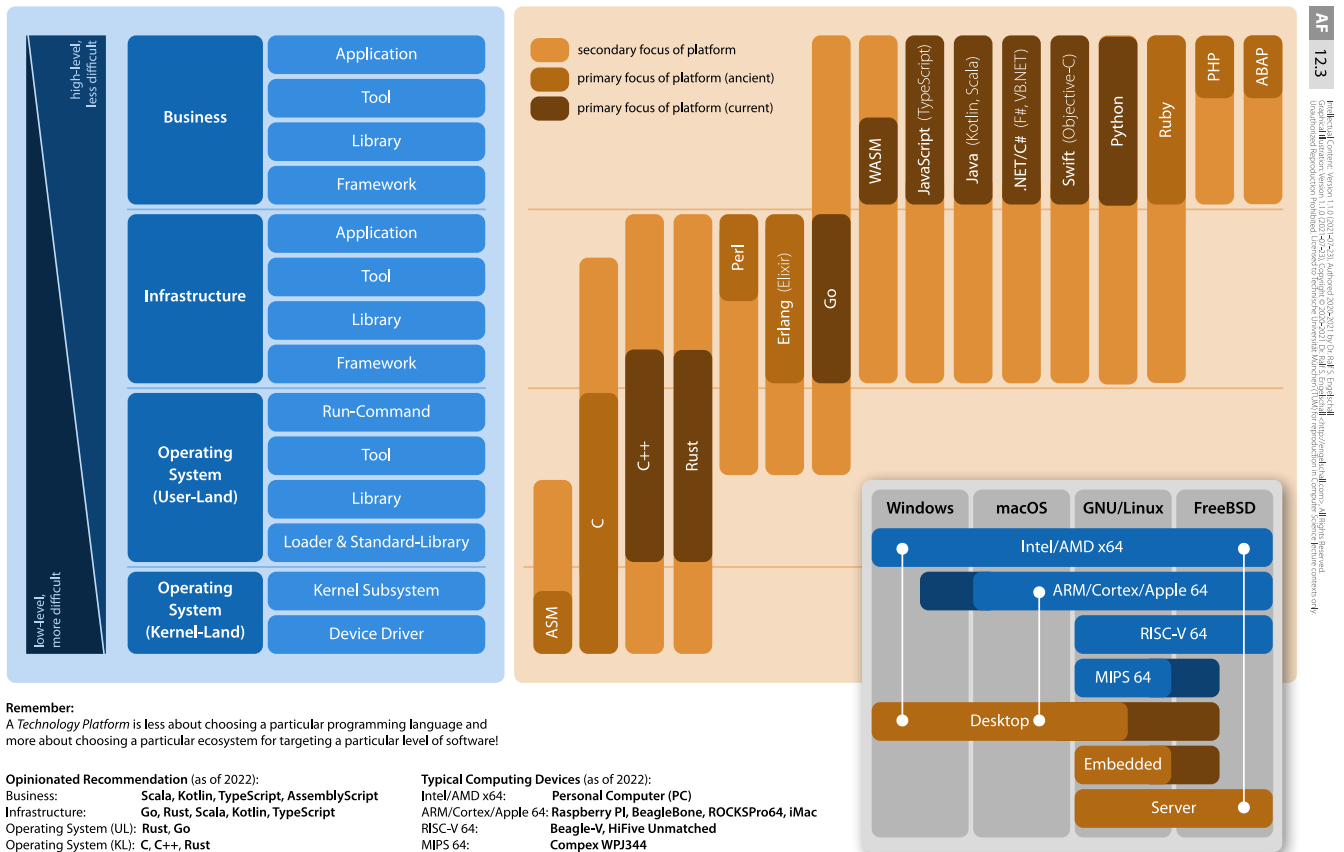
There are innumerable **Formal Languages**. In a technology stack, usually, almost a dozen such languages are used at the same time. The architect must therefore select them very carefully.

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?

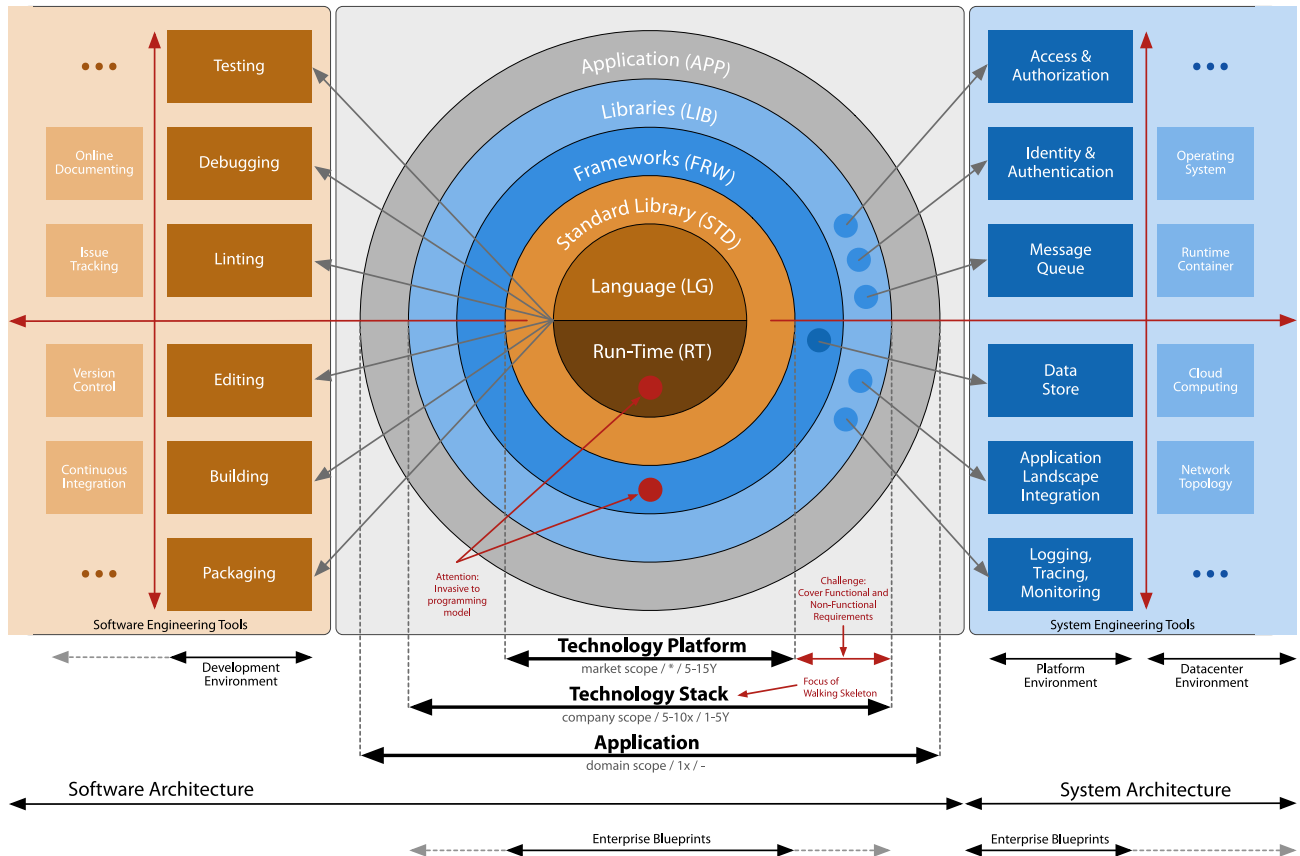


There are various levels of software, ranging from low-level and more difficult (operating system related) to high-level and less difficult (business-logic related).

A Technology Platform is less about choosing a particular programming language and more about choosing a particular ecosystem for targeting a particular kind of software!

## Questions

- ❓ Is the Technology-Platform **Node.js** suitable to implement a Kernel-Subsystem at the level of the operating system?



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?

<b>IT Interface Theme</b> Style Reset, Shape, Color, Gradient, Shadow, Font, Icon Bootstrap    TypoPRO, FontAwesome, Normalize	<b>18 Interface Internationalization</b> Text Internationalization (I18N). VueJS    vue-i18next, I18Next	<b>DL Dialog Life-Cycle</b> Component States, Component State Transitions. ComponentJS    (none)
<b>IW Interface Widgets</b> Icon, Label, Text, Paragraph, Image, Form, Text-Field, Text-Area, Date Picker, Toggle, Radio Button, Checkbox, Select List, Slider, Progress Bar, Hyperlink, Popup Menu, Dropdown Menu, Toolbar, Tooltip, Tab, Pill, Breadcrumb, Pagination, Badge, Alert, Panel, Modal, Table, Scrollbar, Carousel Bootstrap    Select2, SlickGrid, ...	<b>DC Data Conversion</b> Value Formatting, Value Parsing, Localization (L10N). VueJS    Moment, Numeral, Accounting, ...	<b>DS Dialog Structure</b> Component, Model/View/Controller Roles, Hierarchical Composition ComponentJS    ComponentJS-MVC
<b>IL Interface Layouting</b> Responsive Design, Media Query, Frame, Grid, Padding, Border, Margin, Alignment, Force, Magnetism Bootstrap    Swiper, jQuery Page, ...	<b>DB Data Binding</b> Reactive, Observer, Unidirectional, Bidirectional, Incremental VueJS    (none)	<b>SP State Persistence</b> Local Storage, Cookies, Caching (none)    Store.js, JS-Cookie
<b>IE Interface Effects</b> Transition, Transformation, Keyframes, Easing Function, Sound Effect, Physics VueJS    Animate.css, DynamicJS, Howler, ...	<b>PM Presentation Model</b> Parameter Value, Command Value, State Value, Data Value, Event Value, Value Validation, Presentation Logic ComponentJS    (none)	<b>BM Business Model</b> Entity, Field, Relationship, Universally Unique Identifiers (UUID) (none)    DataModelJS, Pure-UUID
<b>II Interface Interactions</b> Mouse, Keyboard, Touchscreen, Gesture, Clipboard, Drag & Drop VueJS    Hammer, Mousetrap, Dragula, ...	<b>DN Dialog Navigation</b> Deep Linking, Routing, Dialog Flow ComponentJS    Director, URL.js	<b>UA Use-Case Authorization</b> User Experience, Dialog Restriction, User, Group, Role, Use-Case, Data, Access. (none)    (none)
<b>IS Interface States</b> Rendered, Enabled, Visible, Focused, Warning, Error, Floating VueJS    (none)	<b>DA Dialog Automation</b> Dialog Macros, Click-Through, Smoke Testing. ComponentJS    ComponentJS-Testdrive	<b>CN Client Networking</b> Request/Response, Synchronization, Push, Pull, Pulled-Push, REST, GraphQL, Authentication, Session. (none)    Axios, Apollo Client
<b>IM Interface Mask</b> Markup Loading, Markup Generation, Virtual DOM, Text, Bitmaps, Vectors, 2D/3D Canvas, Accessibility VueJS    jQuery-Markup, D3, Snap.svg, FabricJS, ...	<b>DC Dialog Communication</b> Service, Event, Model, Socket, Hooks ComponentJS    Latching	<b>ED Environment Detection</b> Runtime Detection, Feature Detection. (none)    Modernizr, FeatureJS, jQuery-Stage

To define a Technology Stack for a **Rich Client**, 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.

In the case of a Thin-Client Architecture (instead of a Rich-Client Architecture), a few aspects like **Client Networking** and **Environment Detection** are omitted. All other aspects are still valid, even if, in the case of a Thin-Client Architecture, the frontend (and thus the aspects of the user interface) of the application runs on the server.

Two important aspects deal with the data model: the **Business Model** is a data model that comes directly from the server and is exactly the same in slicing and granularity than the business data model of the server. Its data is synchronized with a **Presentation Model**, which in slicing and granularity is more like the (more technical) data model of the user interface (especially via the aspects **Interface Mask** and **Data Binding**).

## Questions

- How does one ensure in a **Rich-Client Architecture** that the numerous technical **Aspects** of a user interface are addressed?
- Which two **Aspects** of a **Rich-Client Architecture** hold the data model and take care of the fact that the data supplied by the server cannot be used directly in the user interface?

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

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.

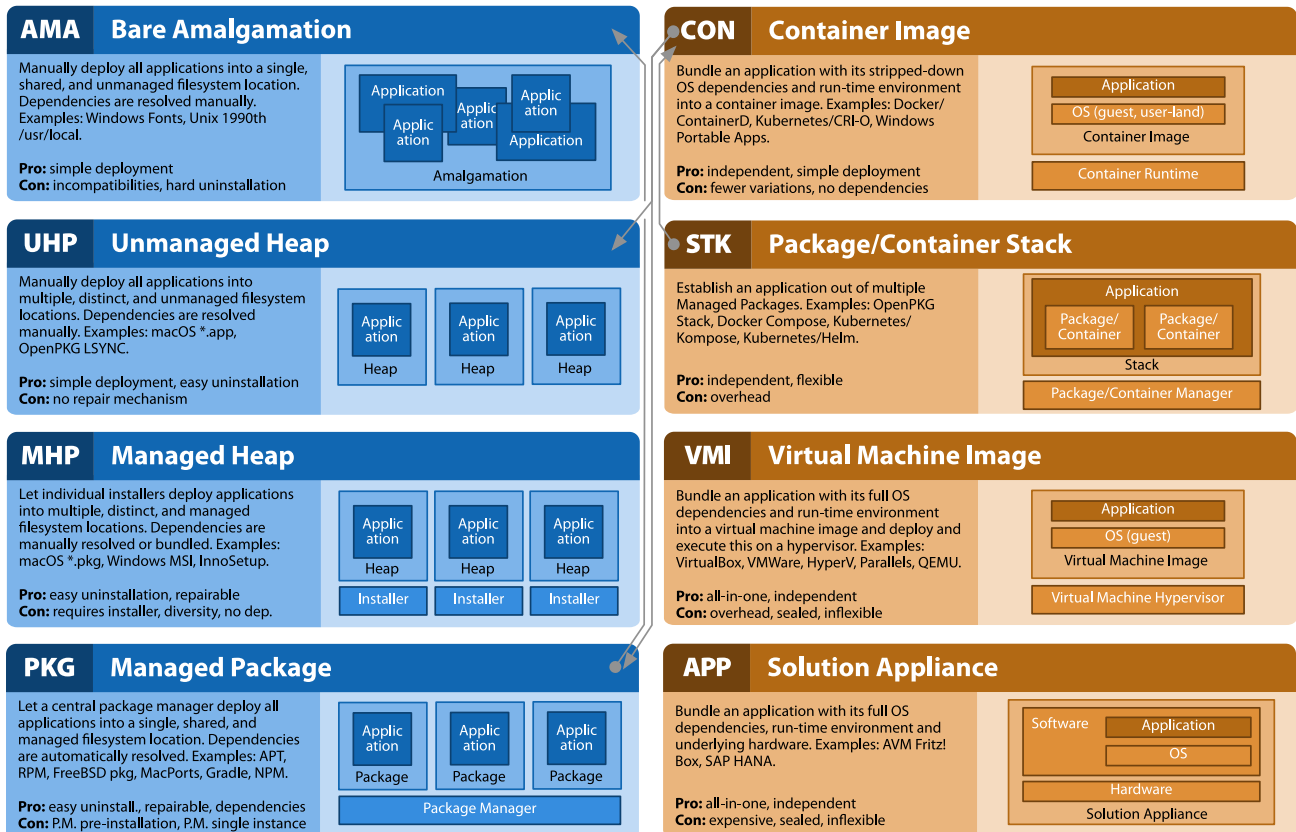
It is to be noted that a server usually does not only have the Aspect **Server Networking** (for the connection of the Rich Clients), but also the Aspect **Client Networking**, in order to be able to query other servers.

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.

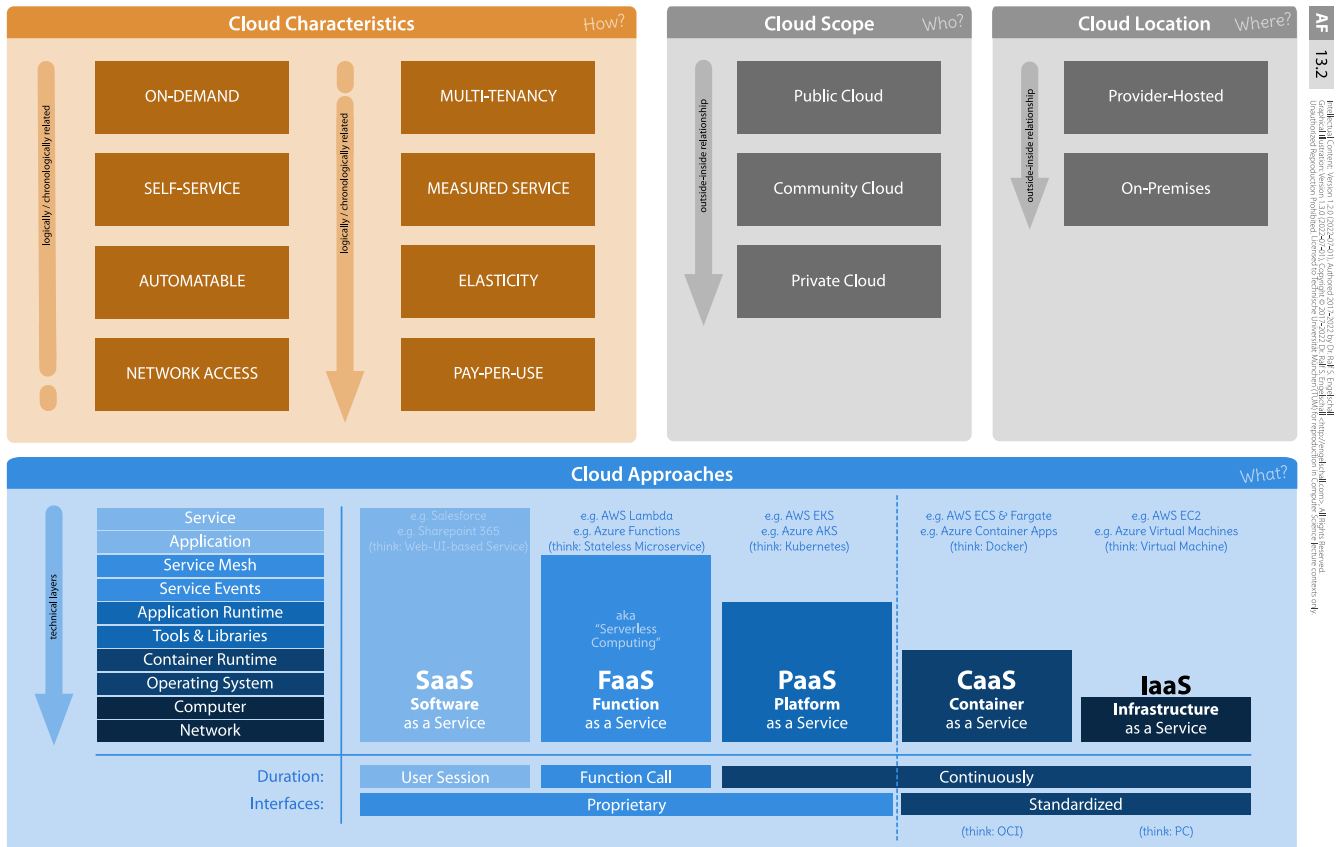
To be more flexible, one can keep the **Managed Packages** or **Container Images** very small and instead define an application through an entire **Package/Container Stack** (e.g., Docker Compose).

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.

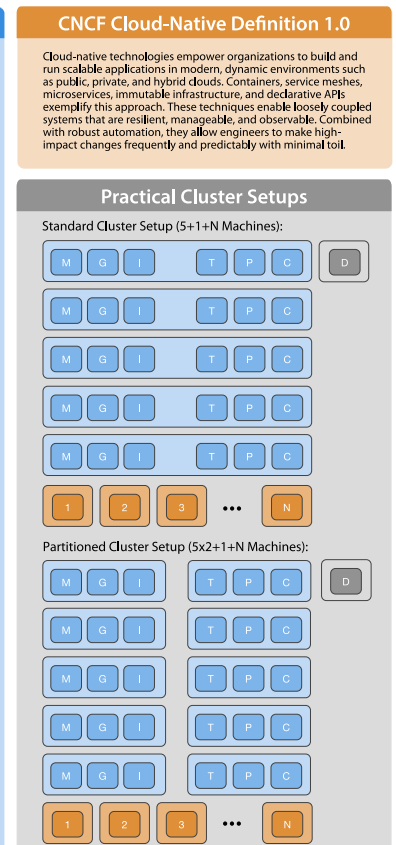
The third dimension **Cloud Scope** (“Who?”), states for whom the resources are provided: **Public Cloud** for public Cloud Computing, **Community Cloud** for Cloud Computing of a closed group of organizations, and **Private Cloud** for Cloud Computing of a single organization.

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?





Preprint JHEP07 (2022) 165  
 Content not for distribution  
 Content Version 1.2.4 (2019-10-30). Authored 2016-2019 by Dr. Ralf S. Engelke  
 Distribution Version 1.2.6 (2022-10-09). Copyright © 2016-2022 Dr. Ralf S. Engelke  
 https://arxiv.org/abs/1605.04693  
 All rights reserved.

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.



Offline capabilities can be essential for an exceptional User Experience of client/server-based Business Information Systems in the context of Cloud Computing. The challenges for the temporary network offline situations include toggled Virtual Private Networks (VPN), switched mobile network cells, and failed network components.

In offline scenarios, during an offline phase, an application can support a particular maturity level: At **Offline Unaware**, the client implicitly fails with network errors; At **Offline Aware**, the client explicitly disables user interface and shows modal error message; At **Offline Read**, the client allows read-operations, but no writeoperations, to locally cached data; At **Offline Read & User-Exclusive Write**, the client allows atomic read-operations to any, and write-operations to userexclusive, locally cached data; At **Offline Read & Atomic Write**, the client allows atomic read/write-operations to any locally cached data; At **Offline Transactional Read / Write**, the client allows non-atomic (transactional) read/ write-operations to any locally cached data.

## Questions

- Why can offline capability of applications be crucial in the context of Cloud Computing?