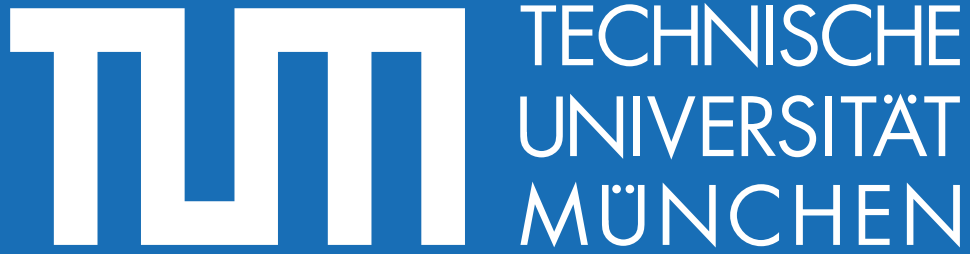

Software Engineering in der industriellen Praxis (SEIP)

Dr. Ralf S. Engelschall

ARCHITECTURE FUNDAMENTALS

Formal Languages

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AF 12.1

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: 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.

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

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

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

Macro Languages

Pre-process texts with macros.

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

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

Expression Languages

Expand path, arithmetic, and boolean expressions.

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

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

Template Languages

Expand complex text fragments.

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

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

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

Examples:
essential
recommended
alternative

ARCHITECTURE FUNDAMENTALS

Technology Platforms

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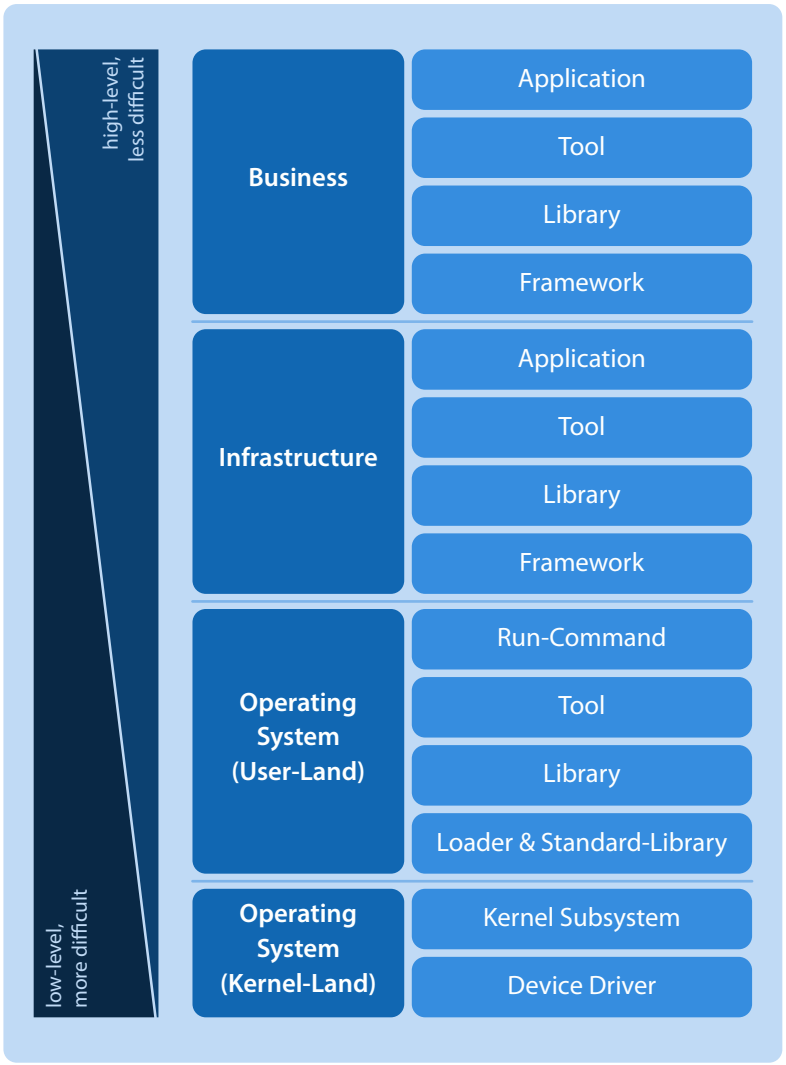

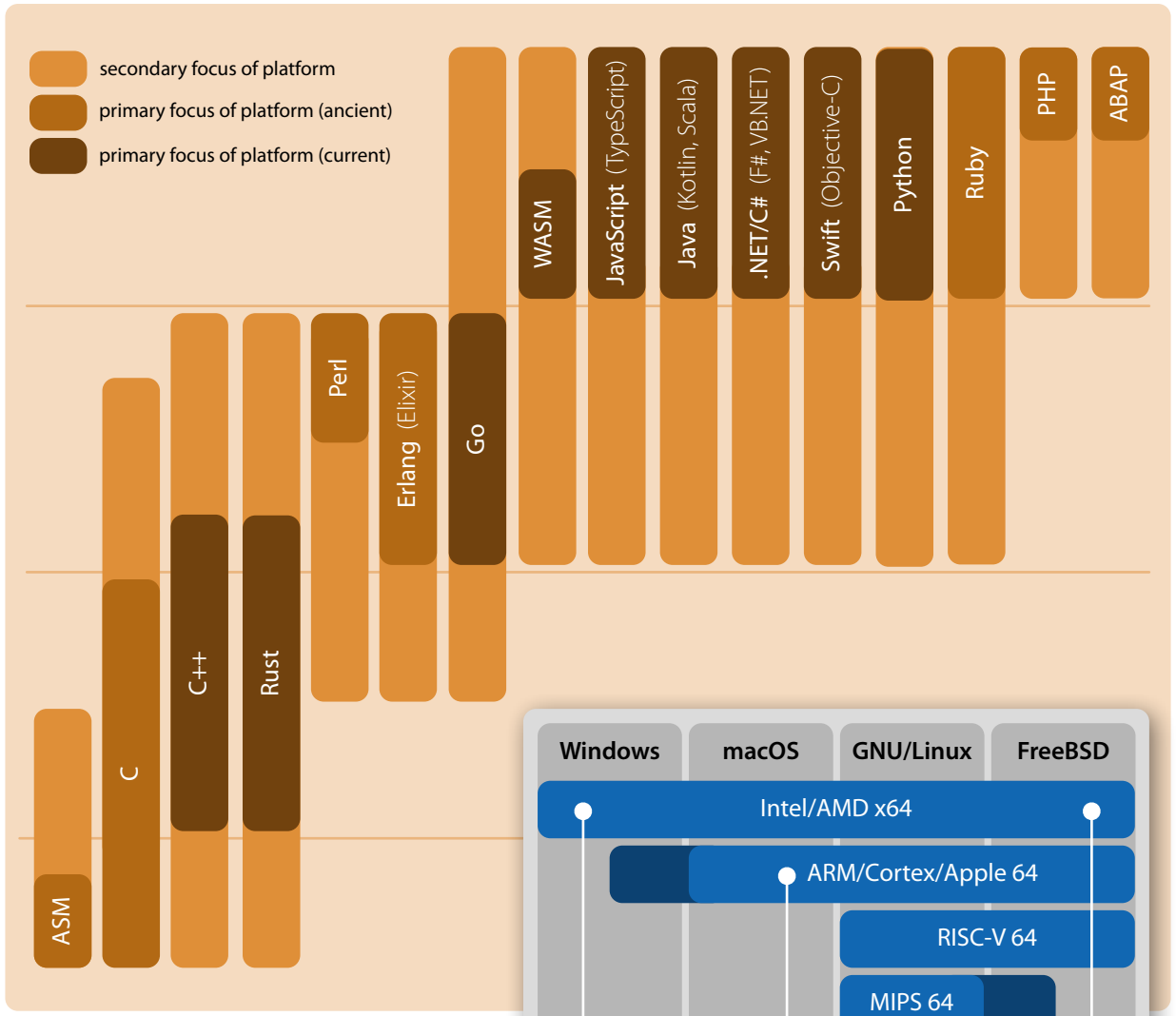

Remember:
A *Technology Platform* is less about choosing a particular programming language and more about choosing a particular ecosystem for targeting a particular level of software!

Opinionated Recommendation (as of 2022):

Business:	**Scala, Kotlin, TypeScript, AssemblyScript**
Infrastructure:	**Go, Rust, Scala, Kotlin, TypeScript**
Operating System (UL):	**Rust, Go**
Operating System (KL):	**C, C++, Rust**

Typical Computing Devices (as of 2022):

Intel/AMD x64:	**Personal Computer (PC)**
ARM/Cortex/Apple 64:	**Raspberry PI, BeagleBone, ROCKSPro64, iMac**
RISC-V 64:	**Beagle-V, HiFive Unmatched**
MIPS 64:	**Compex WPJ344**

ARCHITECTURE FUNDAMENTALS

Technology Stack

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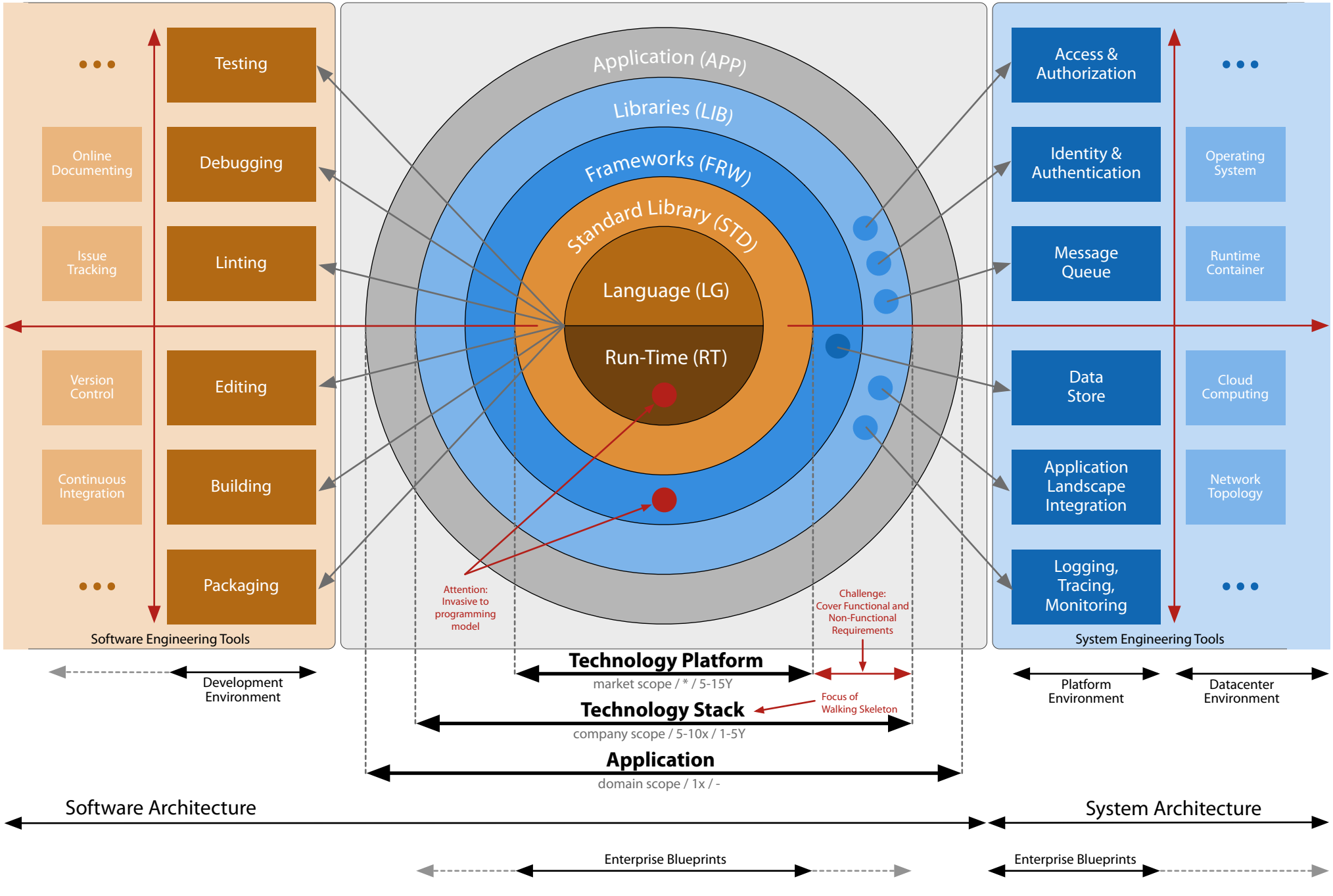

AF 12.4

ARCHITECTURE FUNDAMENTALS

Rich-Client Aspects

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IT Interface Theme

Style Reset, Shape, Color, Gradient, Shadow, Font, Icon

Bootstrap | **TypoPRO, FontAwesome, Normalize**

IW Interface Widgets

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, ...

IL Interface Layouting

Responsive Design, Media Query, Frame, Grid, Padding, Border, Margin, Alignment, Force, Magnetism

Bootstrap | Swiper, jQuery Page, ...

IE Interface Effects

Transition, Transformation, Keyframes, Easing Function, Sound Effect, Physics

VueJS | **Animate.css,** DynamicJS, Howler, ...

II Interface Interactions

Mouse, Keyboard, Touchscreen, Gesture, Clipboard, Drag & Drop

VueJS | **Hammer, Mousetrap,** Dragula, ...

IS Interface States

Rendered, Enabled, Visible, Focused, Warning, Error, Floating

VueJS | (none)

IM Interface Mask

Markup Loading, Markup Generation, Virtual DOM, Text, Bitmaps, Vectors, 2D/3D Canvas, Accessibility

VueJS | **jQuery-Markup,** D3, Snap.svg, FabricJS, ...

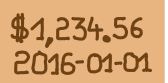
18 Interface Internationalization

Text Internationalization (I18N).

VueJS | vue-i18next, I18Next

DC Data Conversion

Value Formatting, Value Parsing, Localization (L10N).



VueJS | Moment, Numeral, Accounting, ...

DB Data Binding

Reactive, Observer, Unidirectional, Bidirectional, Incremental

VueJS | (none)

PM Presentation Model

Parameter Value, Command Value, State Value, Data Value, Event Value, Value Validation, Presentation Logic

ComponentJS | (none)

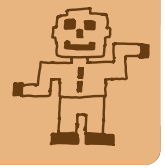
DN Dialog Navigation

Deep Linking, Routing, Dialog Flow

ComponentJS | **Director,** URI.js

DA Dialog Automation

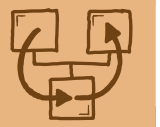
Dialog Macros, Click-Through, Smoke Testing.



ComponentJS | **ComponentJS-Testdrive**

DC Dialog Communication

Service, Event, Model, Socket, Hooks



ComponentJS | **Latching**

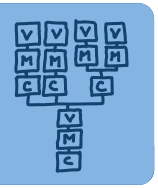
DL Dialog Life-Cycle

Component States, Component State Transitions.

ComponentJS | (none)

DS Dialog Structure

Component, Model/View/Controller Roles, Hierarchical Composition



ComponentJS | ComponentJS-MVC

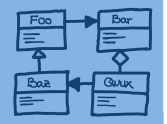
SP State Persistence

Local Storage, Cookies, Caching

(none) | Store.js, JS-Cookie

BM Business Model

Entity, Field, Relationship, Universally Unique Identifiers (UUID)



(none) | DataModelJS, Pure-UUID

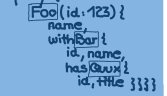
UA Use-Case Authorization

User Experience, Dialog Restriction, User, Group, Role, Use-Case, Data, Access.

(none) | (none)

CN Client Networking

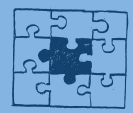
Request/Response, Synchronization, Push, Pull, Pulled-Push, REST, GraphQL, Authentication, Session.



(none) | **Axios,** Apollo Client

ED Environment Detection

Runtime Detection, Feature Detection.



(none) | Modernizr, FeatureJS, jQuery-Stage

AF 12.5

ARCHITECTURE FUNDAMENTALS

Thin-Server Aspects

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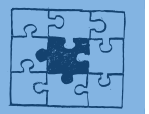
AF 12.6

ED Environment Detection

Detect the run-time environment, like underlying operating system, execution platform, network topology, feature toggles, etc.

Node | process, syspath



AP Argument Parsing

Parse options and arguments of the Command-Line Interface (CLI) to bootstrap application parameters.

(none) | yargs

CP Configuration Parsing

Load and parse directives from configuration file to bootstrap application parameters.

(none) | js-YAML

PD Process Daemonizing

Detdetach from the startup terminal and host process in order to run fully independently.

(none) | daemonize2

PM Process Management

(Pre-)fork child processes and/or threads of execution and monitor and control them during the life-cycle of the application.

(none) | cluster, nodemon

CM Component Management

Structure the code into components, instanciate them under run-time and manage them in a stateful component life-cycle.

Microkernel | (none)

CC Component Communication

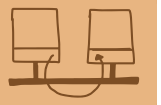
Provide inter-component communication mechanisms like events, hooks, registry, etc.

Microkernel | Latching

SN Server Networking

Listen to network sockets, accept connections and manage request/response and message communication.

HAPI | hapi-plugin-websocket, ws



PI Peer Information

Determine unique identification and add-on information about the client peer.

HAPI | hapi-plugin-peer, geoip

SH Session Handling

Manage secured per-connection sessions to keep state between communication requests and/or client sessions.

HAPI | YAR

UA User Authentication

Determine and validate the unique identity of the user communicating over the current network connection.

HAPI | JWT, Passport

RV Request Validation

Validate the syntactical and semantical compliance of the requests and sanitize the requests.

HAPI | Joi, DuckyJS

RP Request Processing

Process the request by dispatching execution according to the provided request and determined context information.

HAPI | GraphQL.js

RA Role Authorization

Determine whether the role of the current user is allowed to execute the current request.

(none) | GraphQL-Tools-Sequelize

CN Client Networking

Provide mechanisms to connect to peers over the network and perform request/response and/or publish/subscribe communication.

(none) | Axios, MQTT.js, ws

TS Task Scheduling

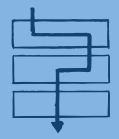
Schedule and execute recurring tasks independent of regular I/O operations.

(none) | node-scheduler

ET Execution Tracing

Provide mechanisms for tracing the execution by logging event and measurement information at certain points of interest.

Microkernel | Winston



DA Database Access

Map in-memory domain entities onto data store dependent persistent data structure.

Sequelize | GraphQL-Tools-Sequelize

DC Database Connectivity

Locally or remotely connect the database access layer to the underlying data store.

Sequelize | sqlite3, pg

DS Database Schema

Create, update or downgrade the data schema inside the underlying data store.

Sequelize | (none)

DB Database Bootstrapping

Create, update or downgrade both mandatory bootstrapping and optional domain-specific data inside the underlying data store.

Sequelize | ini

ARCHITECTURE FUNDAMENTALS

Software Deployment

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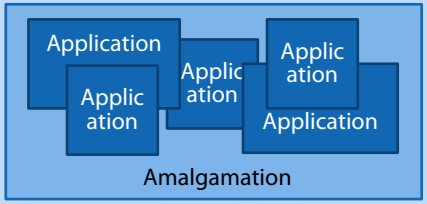
AF 13.1

AMA Bare Amalgamation

Manually deploy all applications into a single, shared, and unmanaged filesystem location. Dependencies are resolved manually. Examples: Windows Fonts, Unix 1990th /usr/local.

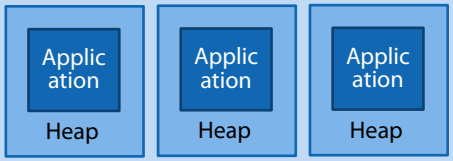
Pro: simple deployment
Con: incompatibilities, hard uninstallation



UHP Unmanaged Heap

Manually deploy all applications into multiple, distinct, and unmanaged filesystem locations. Dependencies are resolved manually. Examples: macOS *.app, OpenPKG LSYNC.

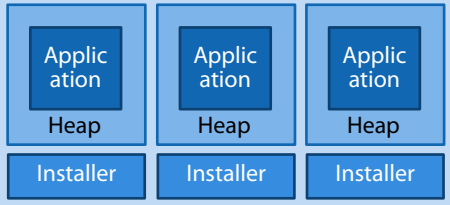
Pro: simple deployment, easy uninstallation
Con: no repair mechanism



MHP Managed Heap

Let individual installers deploy applications into multiple, distinct, and managed filesystem locations. Dependencies are manually resolved or bundled. Examples: macOS *.pkg, Windows MSI, InnoSetup.

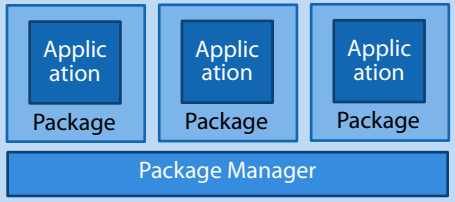
Pro: easy uninstallation, repairable
Con: requires installer, diversity, no dep.



PKG Managed Package

Let a central package manager deploy all applications into a single, shared, and managed filesystem location. Dependencies are automatically resolved. Examples: APT, RPM, FreeBSD pkg, MacPorts, Gradle, NPM.

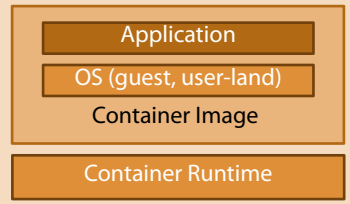
Pro: easy uninstall., repairable, dependencies
Con: P.M. pre-installation, P.M. single instance



CON Container Image

Bundle an application with its stripped-down OS dependencies and run-time environment into a container image. Examples: Docker/ ContainerD, Kubernetes/CRI-O, Windows Portable Apps.

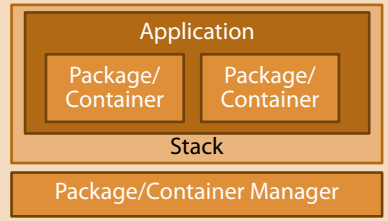
Pro: independent, simple deployment
Con: fewer variations, no dependencies



STK Package/Container Stack

Establish an application out of multiple Managed Packages. Examples: OpenPKG Stack, Docker Compose, Kubernetes/ Kompose, Kubernetes/Helm.

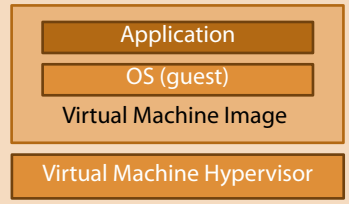
Pro: independent, flexible
Con: overhead



VMI Virtual Machine Image

Bundle an application with its full OS dependencies and run-time environment into a virtual machine image and deploy and execute this on a hypervisor. Examples: VirtualBox, VMWare, HyperV, Parallels, QEMU.

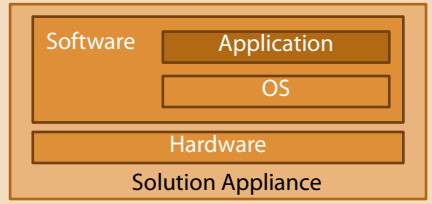
Pro: all-in-one, independent
Con: overhead, sealed, inflexible



APP Solution Appliance

Bundle an application with its full OS dependencies, run-time environment and underlying hardware. Examples: AVM Fritz! Box, SAP HANA.

Pro: all-in-one, independent
Con: expensive, sealed, inflexible



ARCHITECTURE FUNDAMENTALS

Cloud Computing Resources

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AF 13.2

Cloud Characteristics — How?

logically / chronologically related

- ON-DEMAND
- SELF-SERVICE
- AUTOMATABLE
- NETWORK ACCESS

logically / chronologically related

- MULTI-TENANCY
- MEASURED SERVICE
- ELASTICITY
- PAY-PER-USE

Cloud Scope — Who?

outside-inside relationship

- Public Cloud
- Community Cloud
- Private Cloud

Cloud Location — Where?

outside-inside relationship

- Provider-Hosted
- On-Premises

Cloud Approaches — What?

technical layers

- Service
- Application
- Service Mesh
- Service Events
- Application Runtime
- Tools & Libraries
- Container Runtime
- Operating System
- Computer
- Network

	SaaS	FaaS	PaaS	CaaS	IaaS
	e.g. Salesforce e.g. Sharepoint 365 (think: Web-UI-based Service)	e.g. AWS Lambda e.g. Azure Functions (think: Stateless Microservice)	e.g. AWS EKS e.g. Azure AKS (think: Kubernetes)	e.g. AWS ECS & Fargate e.g. Azure Container Apps (think: Docker)	e.g. AWS EC2 e.g. Azure Virtual Machines (think: Virtual Machine)
		aka "Serverless Computing"			
	Software as a Service	**Function** as a Service	**Platform** as a Service	**Container** as a Service	**Infrastructure** as a Service
Duration:	User Session	Function Call	Continuously		
Interfaces:	Proprietary			Standardized	
				(think: OCI)	(think: PC)

ARCHITECTURE FUNDAMENTALS

Cloud-Native Architecture

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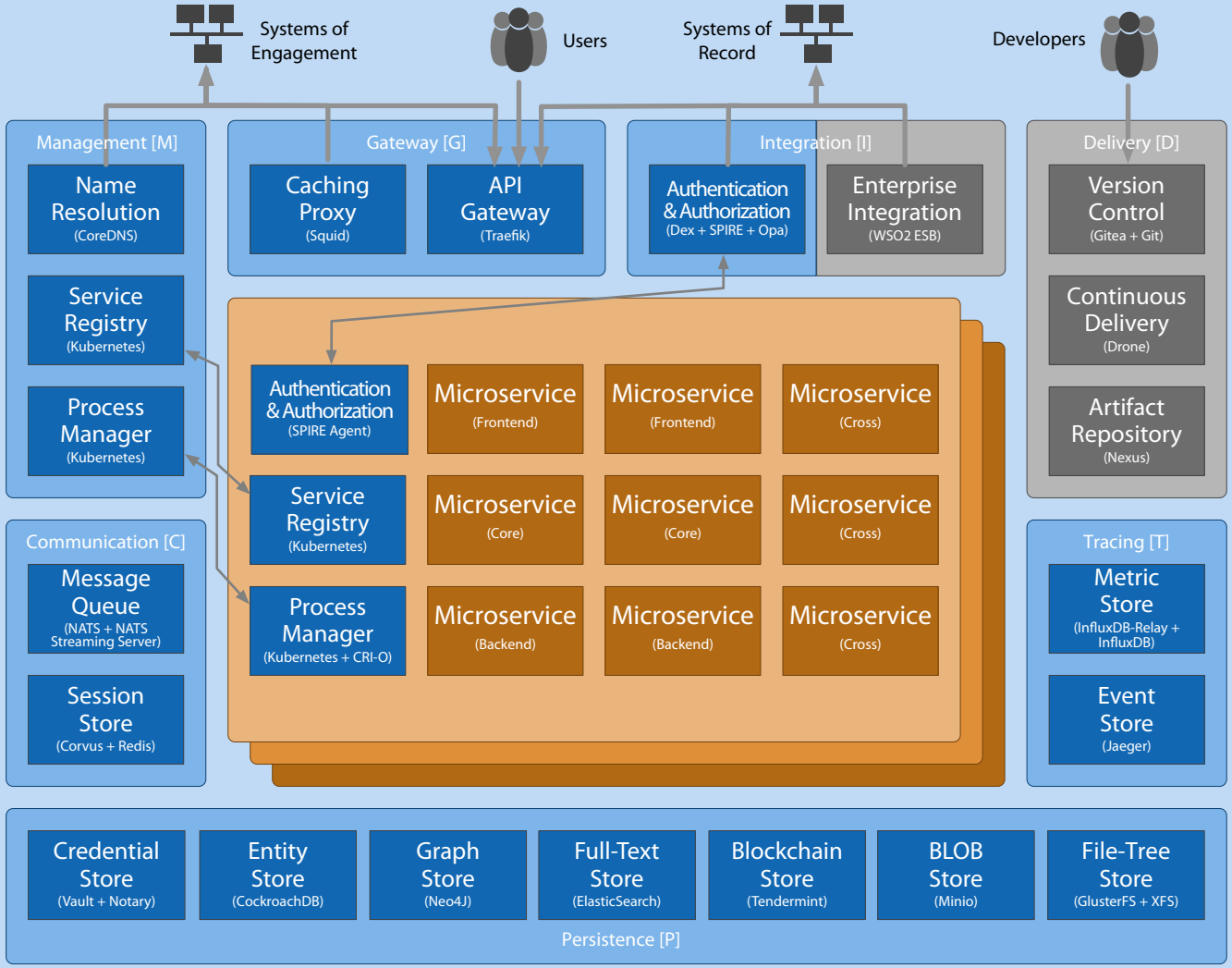
Reference Architecture Blueprint



Major Approach Idea:
With Cloud-Native Architecture one maximizes the leverage of PaaS-like, high-available, and scalable Cloud services at the level of Software- and Systems-Architecture for a whole set of applications.

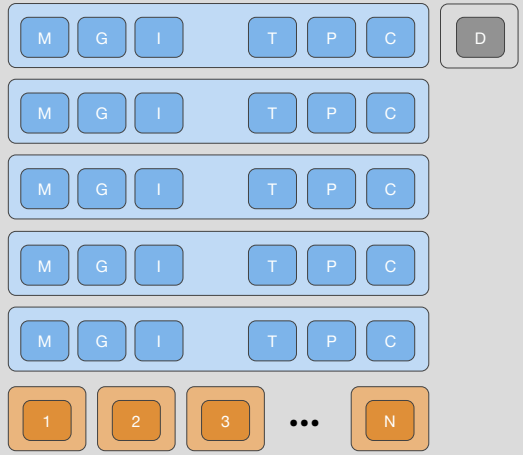
Major Design Criterias:
1. Targets DevOps approach.
2. Targets Continuous Delivery process.
3. Targets Microservice Architecture.
4. Targets Container Image deployment.
5. Targets Service Mesh communication.
6. Targets Server Cluster setup.
7. Provides High-Availability of Service Platform
8. Provides High-Availability of Application Microservices.
9. Provides Scalability of Application Microservices.

CNCF Cloud-Native Definition 1.0

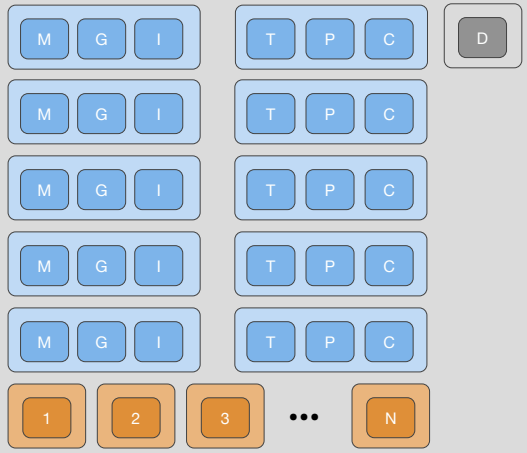
Cloud-native technologies empower organizations to build and run scalable applications in modern, dynamic environments such as public, private, and hybrid clouds. Containers, service meshes, microservices, immutable infrastructure, and declarative APIs exemplify this approach. These techniques enable 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.

Practical Cluster Setups

Standard Cluster Setup (5+1+N Machines):



Partitioned Cluster Setup (5x2+1+N Machines):



AF 13.3

ARCHITECTURE FUNDAMENTALS

Offline Capability

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AF 13.4

GOAL

UX Exceptional User Experience

Provide exceptional *User Experience* by taking temporary client/server network offline situations into account and establish trust in the offline capability of the application.

CONTEXT

IS Business Information Systems

Client/sever applications which drive business processes through use-cases, based primarily on the editing, storing, and retrieving of information.

CC Cloud Computing

On-demand availability of computing resources, especially data storage and computing power, without direct active management by the customer.

CHALLENGES

VPN Toggled Virtual (Private) Networks

Network offline situations caused by the explicit on/off toggling of overlayed *Virtual (Private) Networks* by the user.

MNC Switched Mobile Network Cells

Network offline situations caused by the implicit switching between the mobile network cells by the device during mobile use.

NCO Failed Network Components

Network offline situations caused by the failure of any network components between the client and server tiers of an application.

MATURITY LEVELS

Hint: you cannot solve offline scenarios at the technical level if your use-cases are not already aligned to them.

L2 Offline Read

During offline phase, client allows **read**-operations, but **no write**-operations, to locally cached data.

Data Access Layer Proxy
Web Storage API

L1 Offline Aware

During offline phase, client **explicitly** disables user interface and **shows modal error message**.

Rich-Client
Web Network Information API

L0 Offline Unaware

During offline phase, client **implicitly** fails with network errors.

Thin-Client

Notice: each level increases user experience, but also increases technical complexity.

L5 Offline Transactional Read / Write

During offline phase, client allows **non-atomic (transactional)** read/write-operations to any locally cached data.

SAGA Compensation

L4 Offline Read & Atomic Write

During offline phase, client allows **atomic read/write**-operations to **any** locally cached data.

CRDT, Event Sourcing
CQRS, Optimistic Locking

L3 Offline Read & User-Exclusive Write

During offline phase, client allows atomic **read**-operations to **any**, and **write**-operations to **user-exclusive**, locally cached data.

Data Synchronisation
Last-Win Conflict Resolution