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# Software Engineering in der industriellen Praxis (SEIP)

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## Data Structure Types

### Scalar, Atom, Primitive Type

Plain integer or real number, single character or character string, not indexed and (for string only) accessed in O(1) by character position.

### Tuple, Object, Structural Type, Record

Ordered, fixed-size sequence of scalar elements, each of individual type, indexed by name and accessed in O(1) by element name.

### Sequence, Array, List

Ordered sequence of elements, each of same type, indexed by position and accessed in O(1) or O(n) by element position.

### Set, Bag, Bucket

Unordered set of elements, each of same type, not indexed and accessed in O(1) or O(n) by element reference.

### Map, Hash, Associative Array

Unordered sequence of elements, each of same type, indexed by (scalar) key and accessed in O(1) by key.

### Graph, Nodes & Edges

Unordered set of linked elements (nodes), each of individual type, indexed by (scalar) key and accessed in O(1) by key or by following a directed link (edge).

## Data Evolution Approaches

### In-Place Editing

Modify data through direct in-place editing, overwriting the previous revision.

### Stacking Revisions

Modify data through stacking revisions, preserving all previous revisions. Latest revision is always on top of stack.

### Structural Difference

Modify data through merging, journaled domain-unspecific structural differences.

### Operational Transformation (OT)

Modify data through applying journaled, domain-specific operational transformations.

## Data Sharing Approaches

### Event Sourcing & CRDT

Share data as a chronological sequence of data change events from which the data states can be (re)constructed. Optionally, use a Conflict-Free Replicated Data-Type (CRDT) protocol for the change events.

### Ref-Counting & Copy-on-Write

Share data between resources by using reference-counted data chunks, duplicating a chunk (and resetting its reference count to one) on write operations only and destroying a chunk once the reference count drops to zero.

## Data Store Types

### Key-Value Store

Storage of values in an unordered manner, indexed and queried by key.

Redis, Riak, Memcached, RocksDB, LevelDB

### Large-Object Store

Storage of unstructured binary-large object (BLOB) data and its associated meta-data, indexed and queried by unique id.

Minio, SeaweedFS, AWS S3

### Triple Store

Storage of subject-predicate-object triples, indexed and queried by subject/predicate/object values and example triples.

Redshift, Virtuoso

### File-Tree Store

Storage of unstructured data as named files in a directory tree, indexed and queried by name path from root directory to leave file.

ZFS, XFS, UFS2, APFS

### Graph Store

Storage of values as vertices and edges in a graph, both optionally referencing associated key/value pairs. Indexed and queried by key/value pairs and traversed by following edges.

Neo4J, OrientDB, ArangoDB

### Document Store

Storage of structured "documents", indexed by id and key/value fields and queried by id and example documents.

MongoDB, CouchDB, RethinkDB

### Relational/Table Store

Storage rows of fixed-size, typed value columns, indexed and queried by column values.

PostgreSQL, MariaDB, SQLite, H2, ORACLE DB, IBM DB2

ElasticSearch, Solr, Groonga

### Wide-Column Store

Distributed storage of rows of sparse (often untyped) value columns, indexed and queried by column values.

Cassandra, Memcached, HBase, ScyllaDB

### Time-Series Store

Storage of integer or real values (y-axis) of a time-series (x-axis) into a fixed-size storage format in a round-robin manner where older values are increasingly aggregated (leading to lower resolutions at older times) and finally overwritten.

InfluxDB, MetricTank, RRDTool

### DataVault Store

Long-term historical storage of foreign, arbitrary relational data in a fixed schema of hubs, links and satellites, indexed and queried for analysis and reporting purposes.

DataVault 2.0

### BlockChain Store

Storage of values in an unordered manner within information blocks which are cryptographically chained through their hash values and distributed in a peer-to-peer way.

Ethereum, Quorum, Tendermint, Hyperledger

## Data Guarantees

### CAP (Trade-In)

A distributed data store cannot provide more than two out of three guarantees: Consistency (C), Availability (A), Partition-Tolerance (P). So, it has to choose between Consistency (CP) and Availability (AP) when a network partition or failure happens.



### BASE (NoSQL)

The semantics (usually of NoSQL systems) of (B)asically (A)vailable, (S)oft state, and (E)ventual consistency. BASE systems favor Availability over Consistency in the CAP-context.



### ACID (RDBMS, NewSQL)

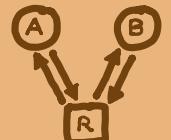
The four guarantees provided in parallel (usually by RDBMS and NewSQL systems): Atomicity, Consistency, Isolation and Durability. ACID systems usually favor Consistency over Availability in the CAP-context.



## Data Access

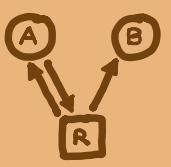
### Shared Read/Write

Shared access to data for both read and write operations. Example: Multiple threads on heap or Master-Master database setup.



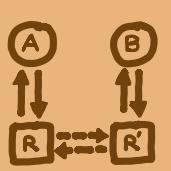
### Shared Read / Exclusive Write

Shared access to data for read operations and exclusive access (via a single "owning" component) to data for write operations. Example: RDBMS Master-Slave cluster with shared storage.



### Shared Nothing

No shared access to data at all for both read and write operations. Example: Leader-Follower setup with RAFT consensus where Leader writes data only.



## Data Access Grouping

### Transaction

Protect a sequence of operations from interim exceptions by bracketing the operations in a technical transaction (ensuring that either all or none of the operations succeed).



### Compensation

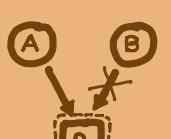
Protect a sequence of operations from interim exceptions by undoing the already succeeded operations through domain-specific compensating (reverse) operations.



## Data Consistency

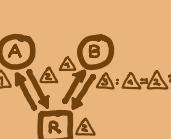
### Exclusive Locking (Mutex)

Protect data from concurrent access and resulting inconsistencies with a mutual exclusion lock (mutex) which allows just a single peer to access the data at a time.



### Optimistic Locking

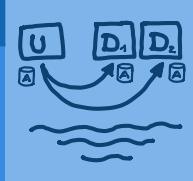
Protect data from concurrent access and resulting inconsistencies by taking note of a revision number or content hash during read operations and checking that this information has not changed before writing the data.



## Data Spreading & Aggregation

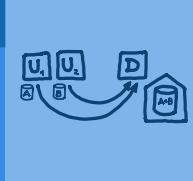
### Data River (1-to-N)

A real-time fan-out replication of data from a single upstream/source data repository to multiple downstream/target data repositories.



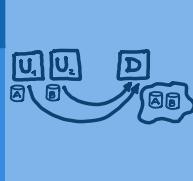
### Data Mart (N-to-1), ODS

A massive sized, easily accessible data repository for storing "big data" from many upstream sources in a (real-time) and structured way and with knowing the actual subsequent analysis usage.



### Data Lake (N-to-1), Cache

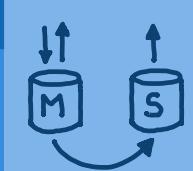
A massive sized, easily accessible data repository for storing "big data" from many upstream sources in a (real-time) semi-structured way and without knowing the actual subsequent usage.



## Data Transfer

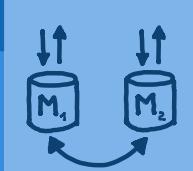
### Replication

Continuously stream or regularly copy data from a master system to one or more slave systems in order to either read the data from slave systems faster or have slave systems available as a fallback/backup in case of a failure of the master system.

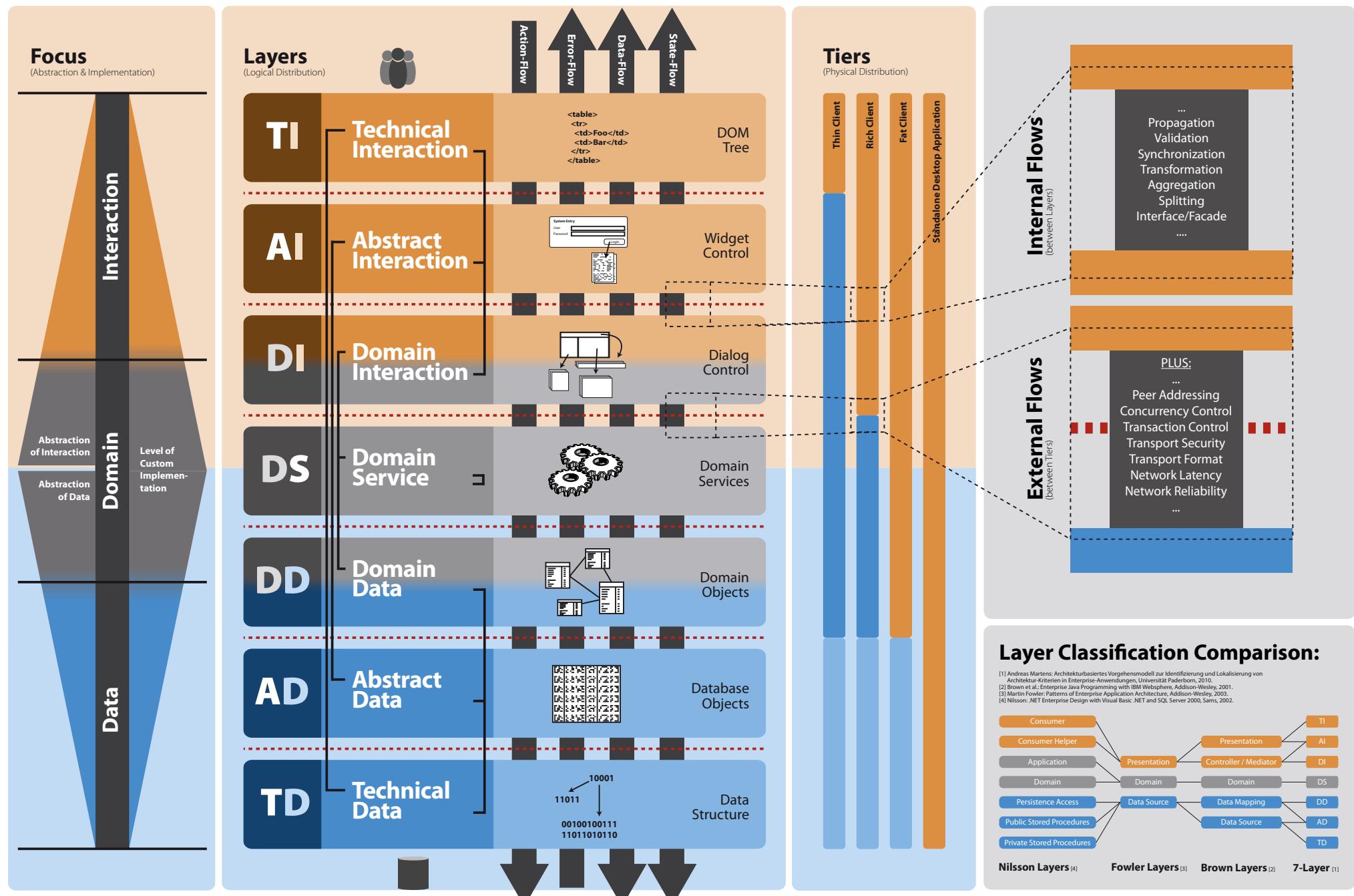


### Synchronization

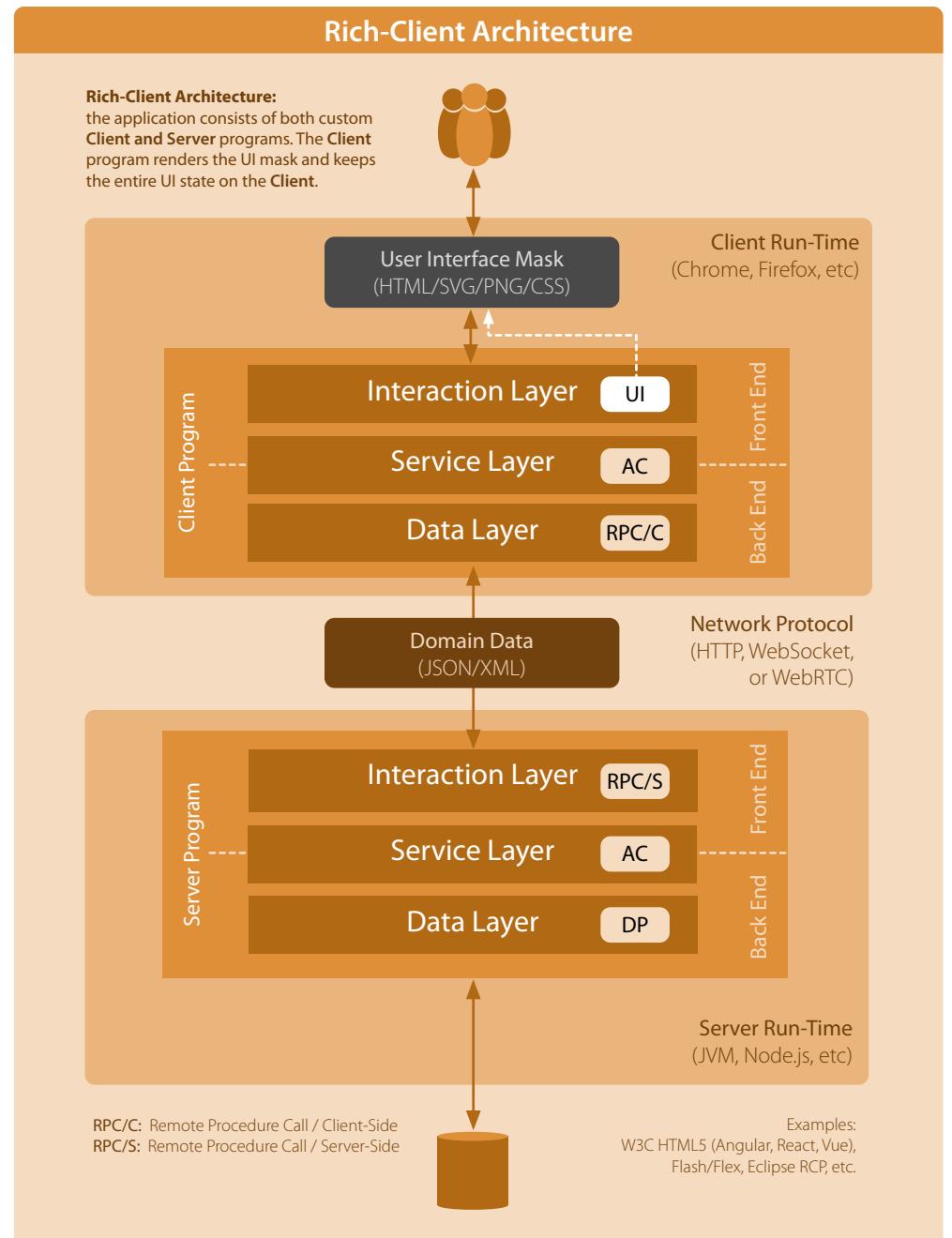
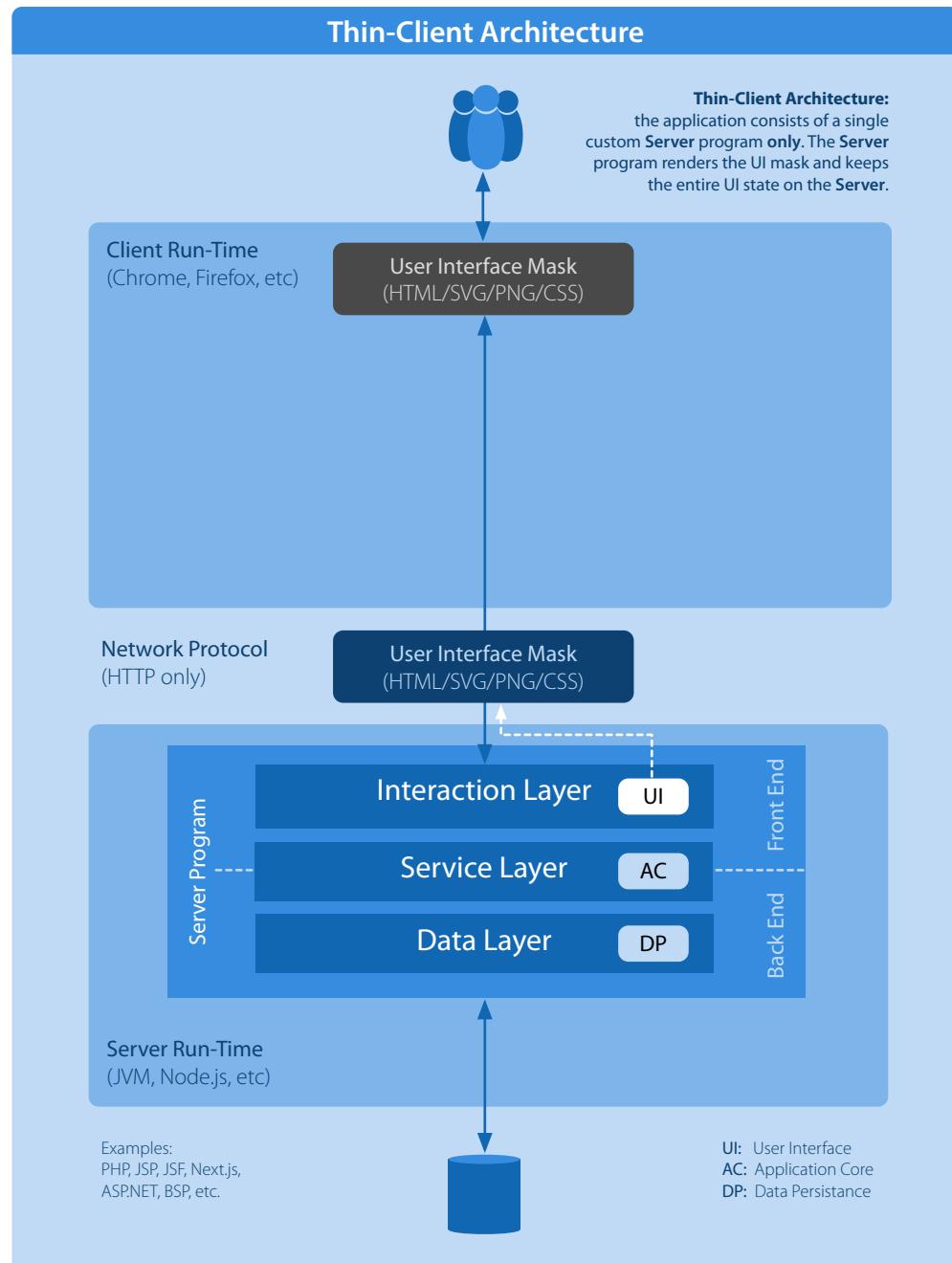
Continuously stream or regularly copy data between multiple master systems and resolve potential concurrent data modification conflicts. This way allow distributed and even disconnected computing.

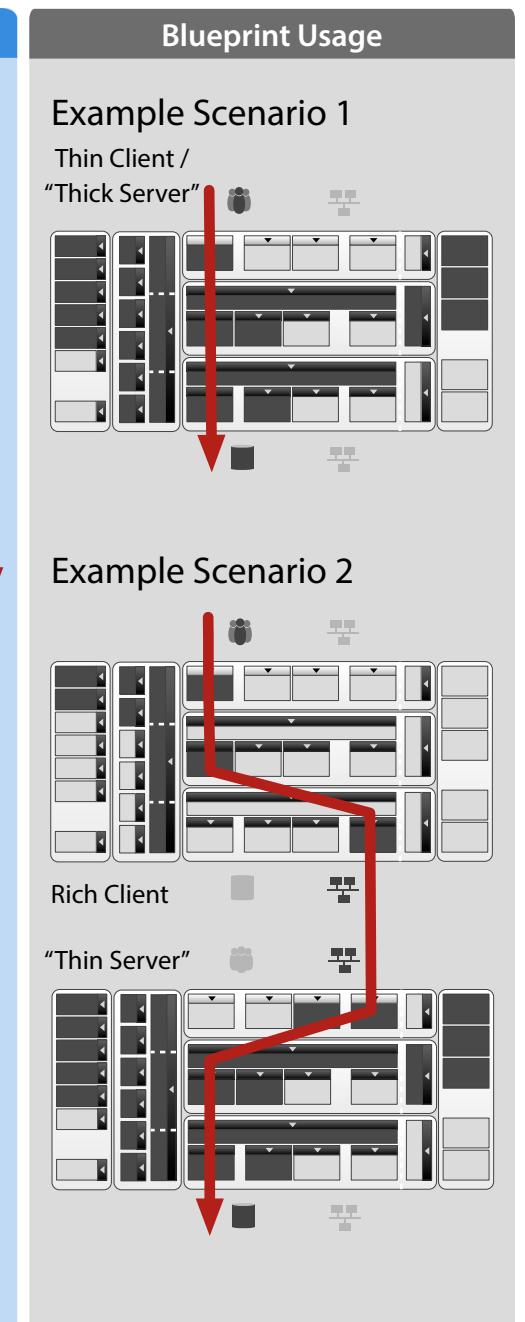
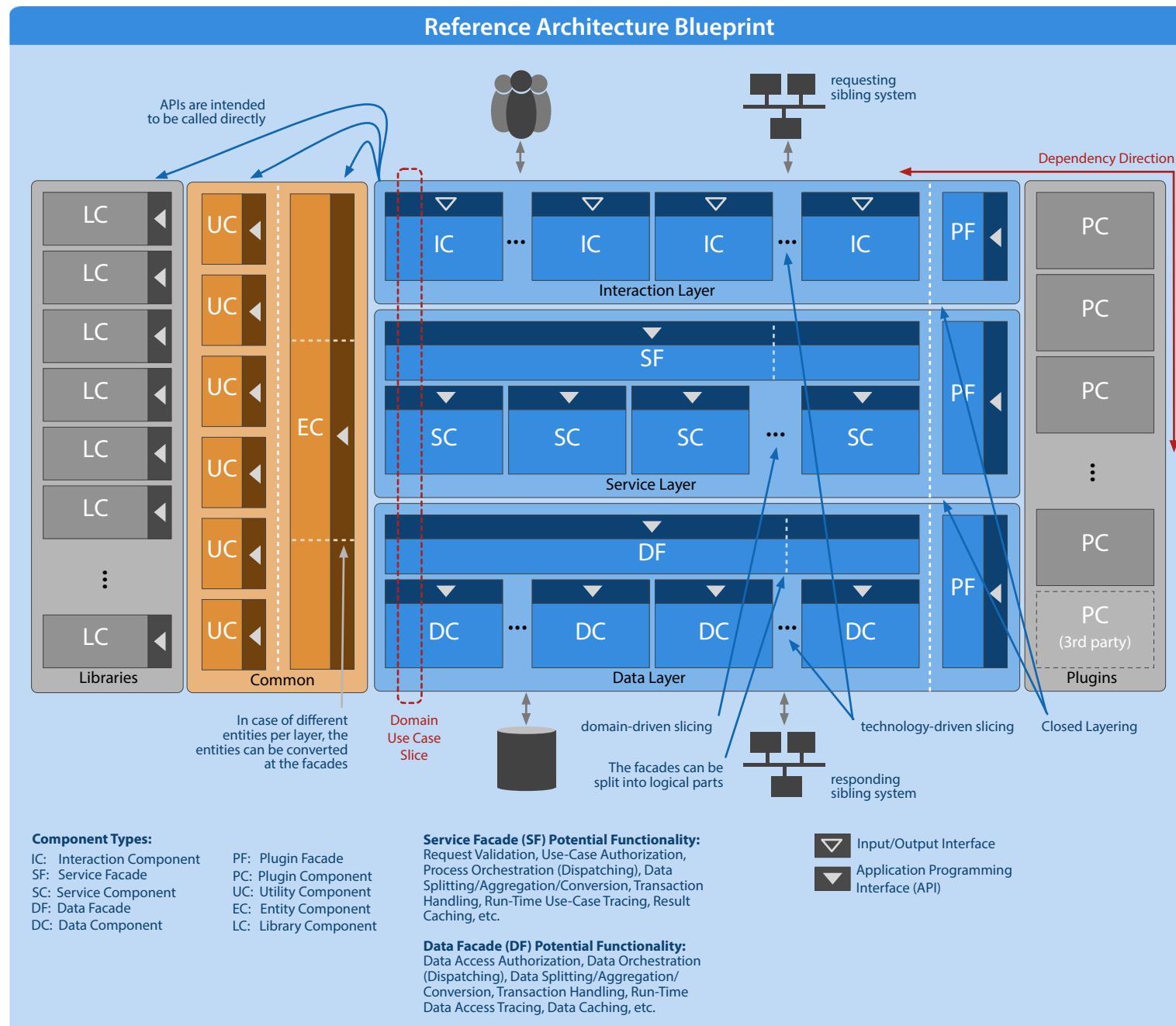


# Application Reference Architecture



# Client-Server Architecture



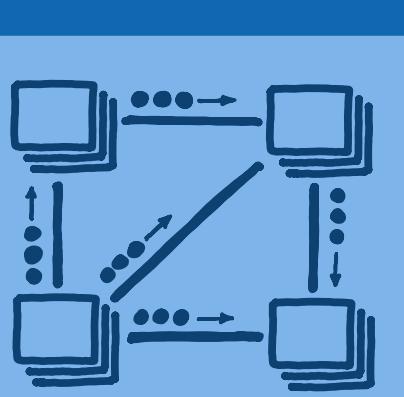


## Architecture & Systems

**DEF Definition**

*Reactive System Architecture enables the realization of Reactive Systems.*

Reactive Systems are in *subordinated interaction* with their *dominating environment*. They *continuously process endless data streams as small messages*, react at *any time* and respond within *tight time limits*. For this, they continuously *observe their environment* and adapt their behaviour to the current situation.



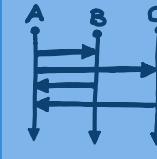
**CTX Context**

*Real-time communication in the context of Digitization, Internet, Internet of Things (IoT), Systems of Engagement, Media and Analytics.*



**VAL Values**

*Non-blocking input/output data processing, fast responses within tight time limits, and continuous availability of the provided services.*



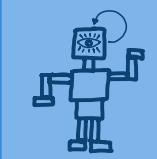
**REQ Requirements**

*Services are elastic and provide high scalability, and are resilient and provide high fault tolerance.*



**PRP Properties**

*Services run fully autonomously, monitor themselves, and automatically adapt to changes in the environment.*

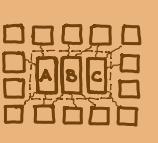


Principles							
<b>Stay Responsive</b> Always respond in a timely manner.	<b>Accept Uncertainty</b> Build reliability despite unreliable foundations.	<b>Embrace Failure</b> Expect things to go wrong and design for resilience.	<b>Assert Autonomy</b> Design components that act independently and interact collaboratively.	<b>Tailor Consistency</b> Individualize consistency per component to balance availability and performance.	<b>Decouple Time</b> Process asynchronously to avoid coordination and waiting.	<b>Decouple Space</b> Create flexibility by embracing the network.	<b>Handle Dynamics</b> Continuously adapt to varying demand and resources.

## Patterns & Paradigms

**ARC Architecture**

Microservices, Cloud-Native Architecture (CNA), Event-Driven Architecture (EDA).



**COM Communication**

Asynchronous Communication, Non-Blocking I/O, Sequence, Push, Backpressure, Quality of Service (QoS).



**DAT Data**

Semantical Event, Small Message, Endless Stream.



**STY Style**

Functional Programming, Asynchronous Programming.



**EXE Execution**

Parallelization, Concurrency, Actors, Threads, Thread-Pool, Event-Loop.



**INF Infrastructure**

Message Queue (MQ), Load Balancer, Reverse Proxy, Service Mesh, Virtual Private Network (VPN).



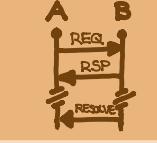
**PRC Processing**

Complex Event Processing (CEP), EAI Patterns, Stream Processing (map, flatMap, filter, reduce), Event Sourcing.



**ASY Asynchronism**

Callback, Promise/Future, Observable, Publish & Subscribe.



**AF** 10.4

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