Data Warehousing
Architecture

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Dr. Andreas Geppert
geppert@acm.org

Outline of the Course

- Introduction
- **DWH Architecture**
- DWH-Design and multi-dimensional data models
- Extract, Transform, Load (ETL)
- Metadata
- Data Quality
- Analytic Applications and Business Intelligence
- Implementation and Performance

Lecture Outline

1. What is “Architecture”?
2. DWH-Architectures
3. DWH-Reference Architectures
4. DWH-Platforms

What is “Architecture”

- Description of the important elements and their relationships in a system
- Architectural styles
- Architecture standards

Enterprise Architecture

- No (apparent) planning
- Anything can be built anywhere

- Source: http://lewishistoricalsociety.com/wiki2011/article_image.php?id=124

- Overall plan
- Infrastructure by design

- Source: http://upload.wikimedia.org/wikipedia/commons/f/fc/Hongkong_central_kowloon-full.jpg

General Architecture Goals

- (Design) blueprints
- Standardization
- Target state of a strategy
- Reuse:
  - Of components
  - Of designs, experiences, entire architectures
- Understanding
- Communication

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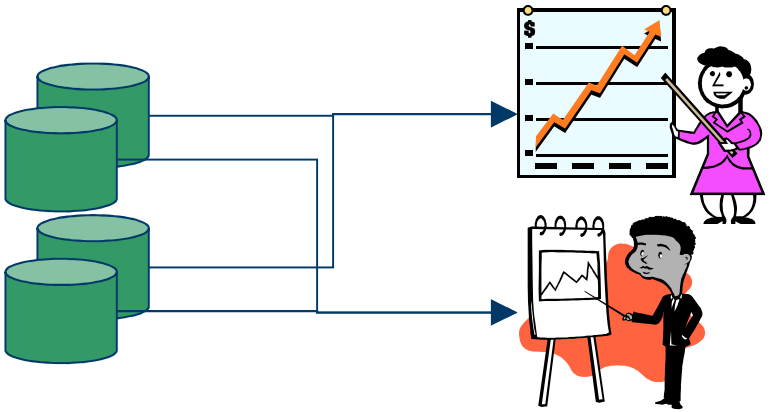
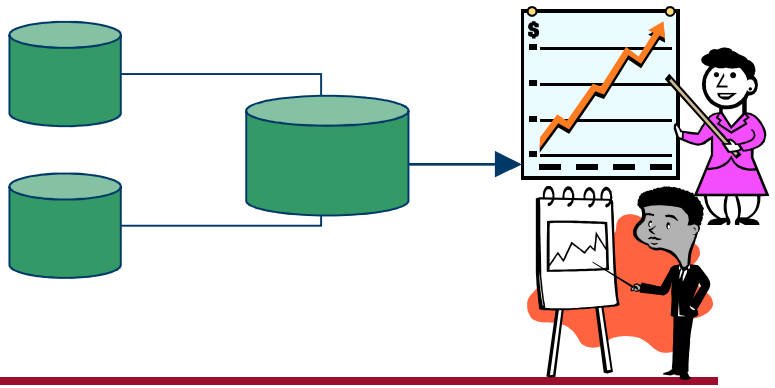
1. What is “Architecture”?
2. **DWH-Architectures**
3. DWH-Reference Architectures
4. DWH-Platforms

Scope of a DWH

- Different architecture styles are adequate for different scopes
- Departmental DWHs implement some or all of the requirements of a single department



- enterprise DWHs integrate all the company's data and make them accessible to analytic applications



Strategic Role of a DWH

- Strategic DWH:
  - Regarded as mission-critical tool for the analysis and optimization of business processes
  - Built and used with a long-term view
- Tactical DWH:
  - Built for a concrete, single, and restricted purpose
  - Built as fast as possible to make analysis available as soon as possible

↳ Depending on the strategic role, different architecture approaches are reasonable and practicable

DWH Architecture Requirements: Functional

- Integration
  - Sourcing of data from relevant data sources
  - Integration and homogenization
  - Historization of data
  - Current data
  - Data quality assurance
  - "single source of truth" respectively "single version of the truth"
- Analysis
  - Support for adequate analysis technologies
  - Multi-dimensionality
  - Consistent reporting

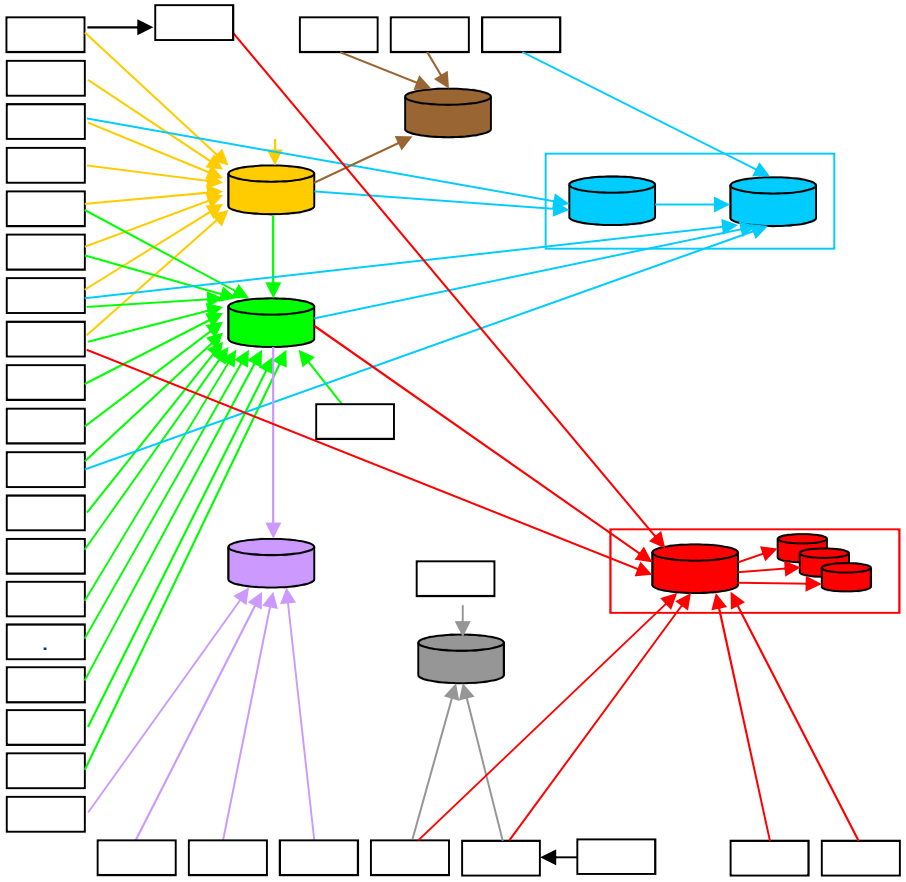
DWH Architecture Requirements> Non-functional

- Extensibility
  - New sources
  - New analysis applications
- Performance
  - Analysis performance
  - Processing time
- Scalability
- Time-to-Market
- No impact on operational applications
- Availability
- Cost effectiveness

DWH-Architecture: ad-hoc

DWH without explicit Architecture

- Flexible for some time, then turns into barely extensible system
  - Most of the efforts goes into maintenance of the current state (KTLO)
- isolated
- expensive
- Difficult to maintain
- No single version of the truth
- Inconsistent reporting
- Probably incomplete



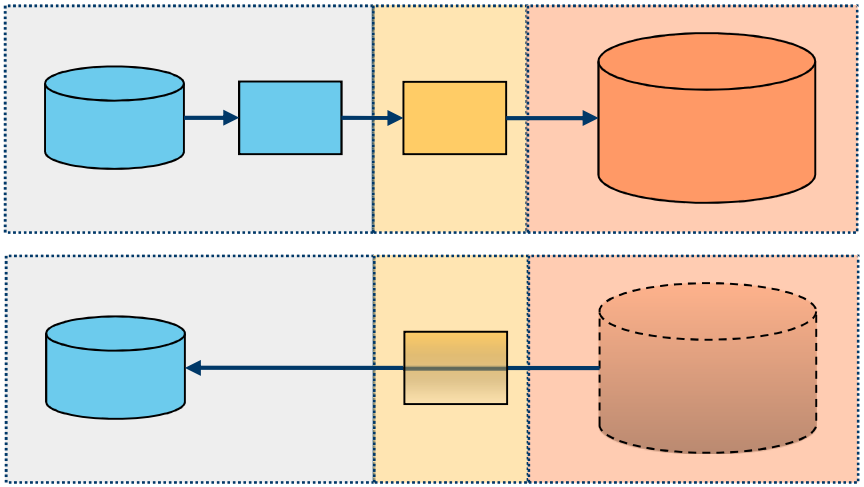
↳ Only adequate for tactical and departmental DWHs

DWH-Architectures (Ariyachandra & Watson 2005)

- Independent data marts
- Data Mart Bus
- Hub and Spoke
- Central Data Warehouse
- Federated Data Warehouse

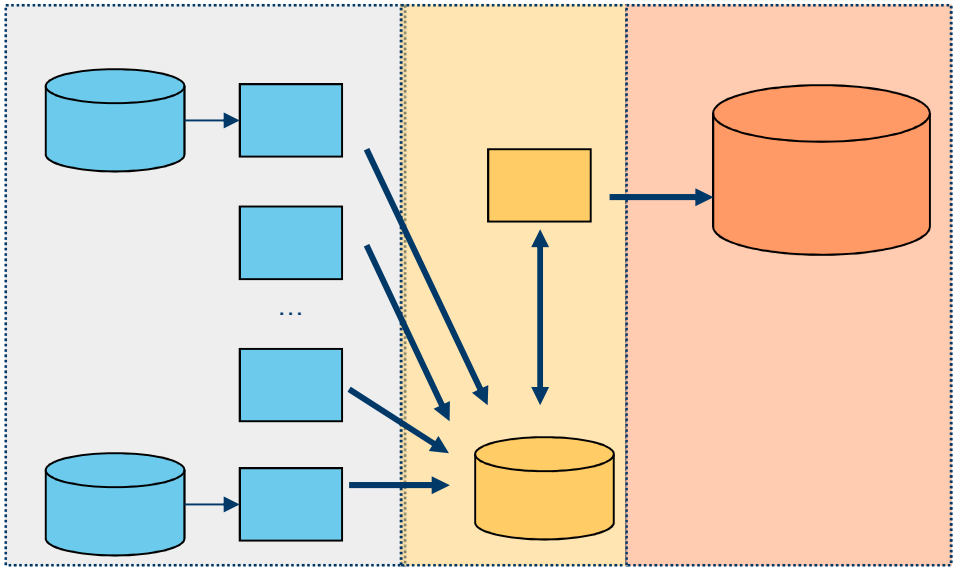
Data Integration

- virtual vs. physical
  - physical: data are copied from sources into the DWH
  - Virtual: data are kept only in sources and are integrated at runtime with other data
- End-of-day vs. Real-time
  - EOD: data are extracted regularly (e.g., at end of the day)
  - (Near) real-time: data are loaded continuously

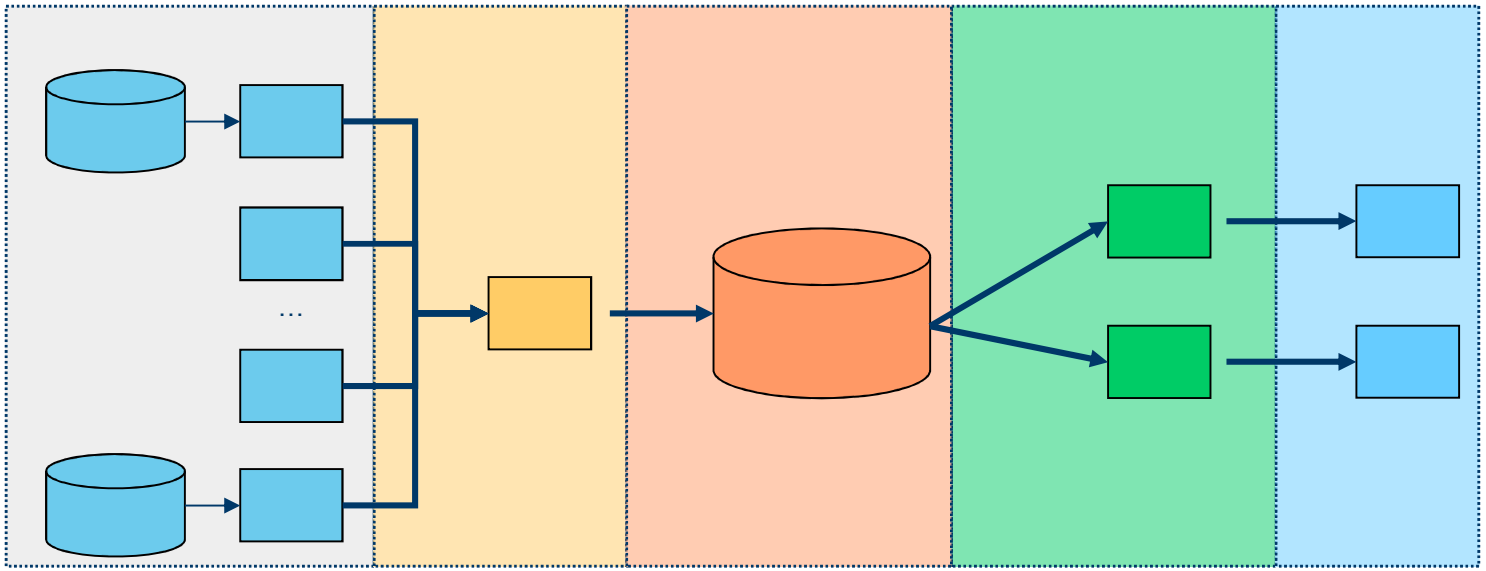


Extraction, Transformation, Loading

- ETL-Processes and tools
- **E**xtraction of data (out of sources)
- **T**ransformation (→ Integration)
- **L**oading of the transformed data into the DWH
- Here ETL is shown with an own staging area for transformations



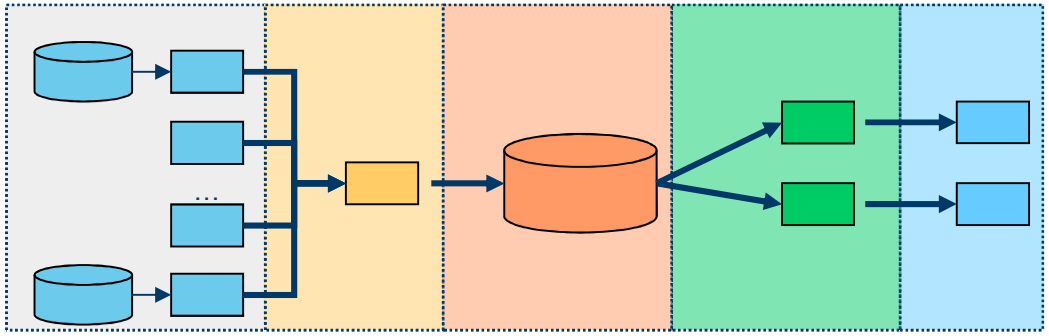
Single-Layer DWH-Architecture



- Integration and ...
- Analysis in the same database (but separated from OLTP)
- **Centralized data warehouse**

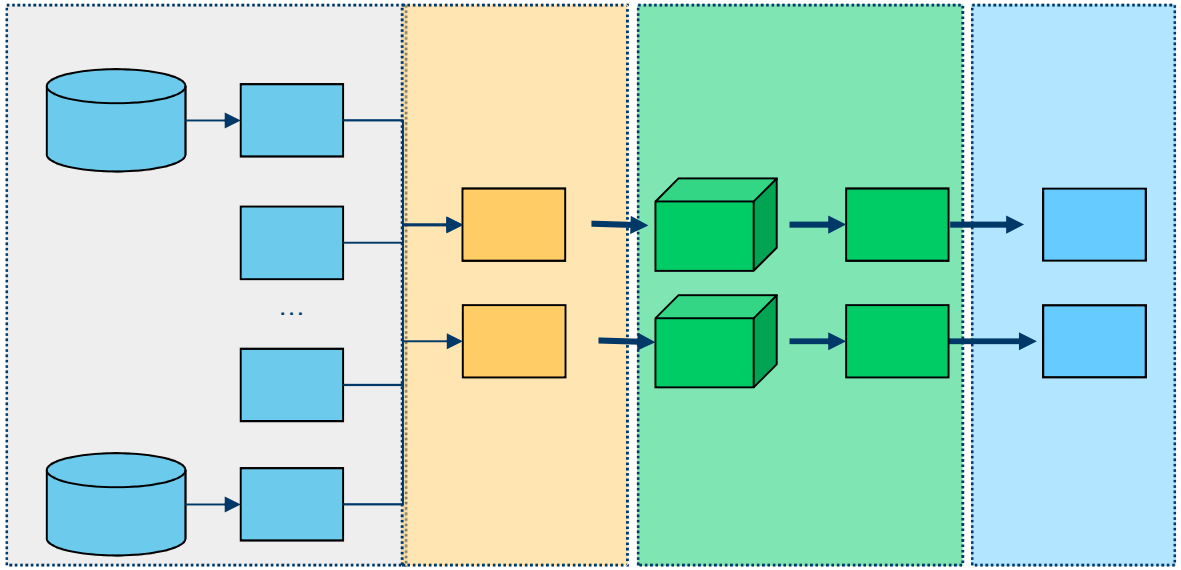
Single-Layer DWH-Architecture

- Impact for enterprise-wide DWHs:
  - Integration of all data sources
  - Support for all analysis needs
- A single system must satisfy all (even diverging) requirements
- Integration and analysis requirements may conflict
- Analysis requirements (from different users) may also conflict



Independent Data Marts

- Multiple data marts (small data warehouses)
- No common, shared integration -> independent data marts
- No central, physical data warehouse



Data Marts

- DWHs are typically designed independently from analysis needs

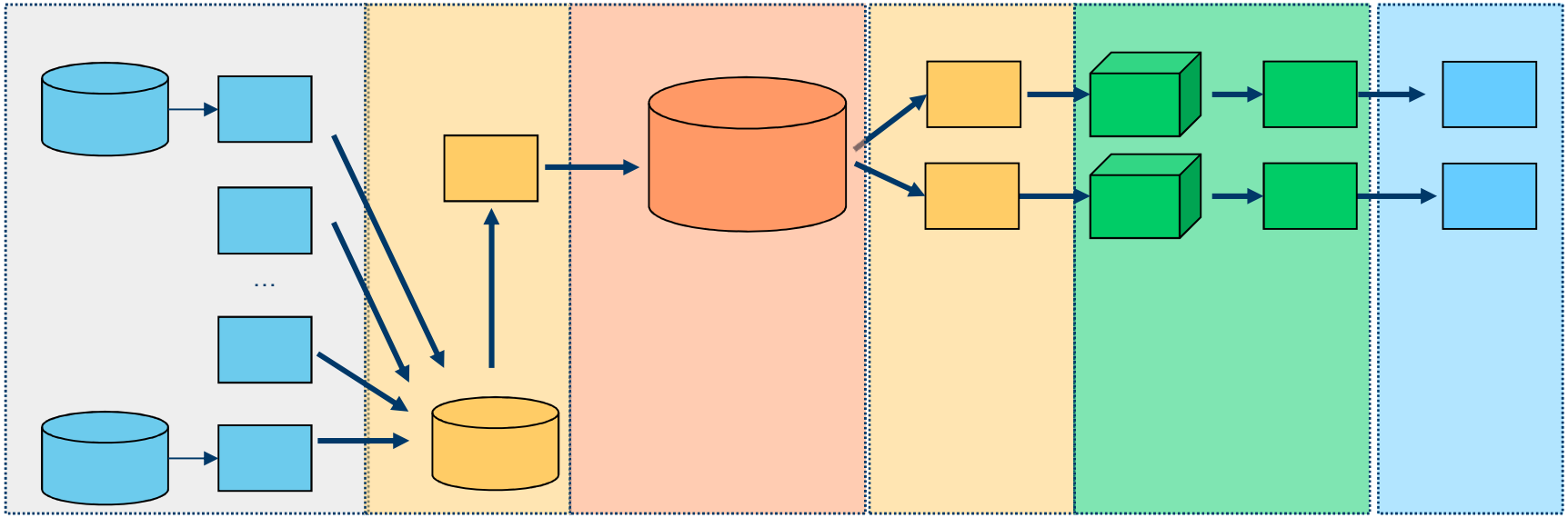
➔ Typical DWH structures can be hard (inefficient) to use for analysis

➔ Build database that is tailored for analytic use

  - ➔ Dimensional view
  - ➔ Aggregation
  - ➔ Selection

- Separation of concerns between DWH (integration) and data mart (analysis)
- “dependent" Data Marts
- **Hub and Spoke**

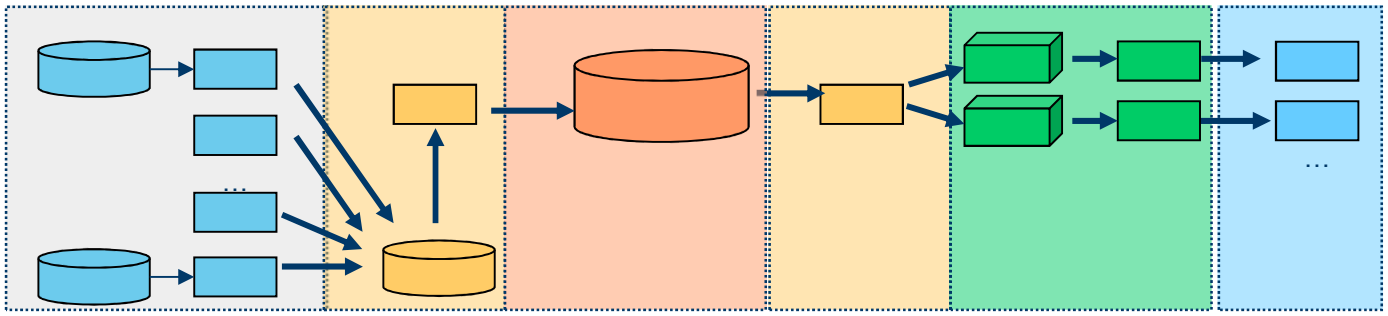
DWH-Architecture with Multiple Data Marts



- Can support a broad spectrum of users and analysis needs
- Customized data mart design
- Can even support different technologies for data marts (relational, non-relational)

DWH-Architecture with Multiple Data Marts

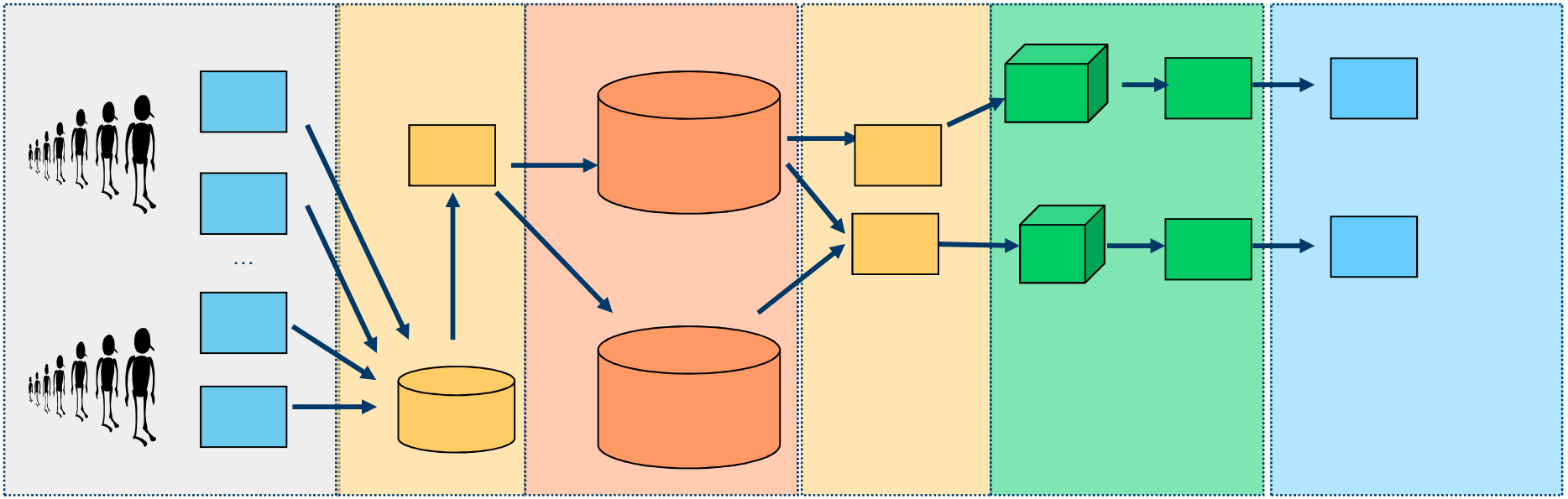
- ☹ Higher redundancy
- ☹ Higher processing overhead
- ☺ Data mart tailored for analysis
  - complexity
  - Performance
- ☺ Loading of data marts can be parallelized



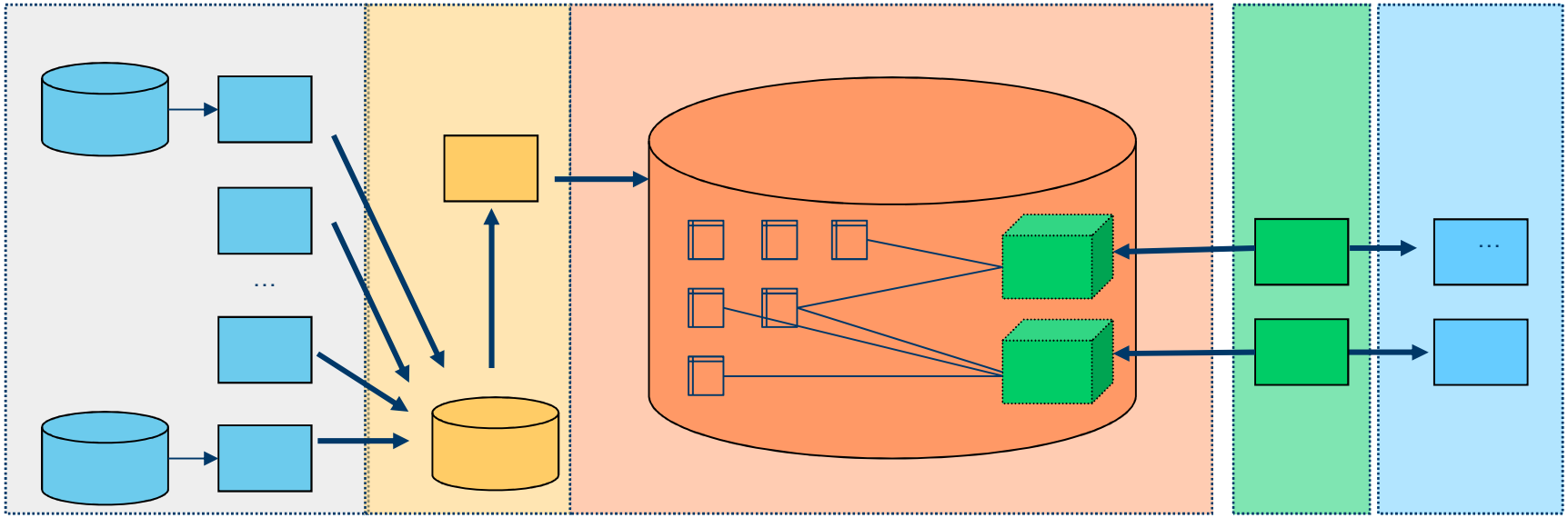
Structure of the DWH / Integration Layer

- DWH-DB is logically (!) structured into multiple logical databases
- Logical databases are defined according to domains (Business Areas, Subjects)

➔Sample domains in a bank: payments, credits, customers, …



DWH-Architecture with Virtual Data Marts



DWH-Architecture with Virtual Data Marts

- Data are not materialized (i.e., stored) in data marts
- Data marts are defined as database views over base tables in the DWH
- ETL logic coded in view definitions

☹ higher complexity

☹ challenging requirements against the DBMS

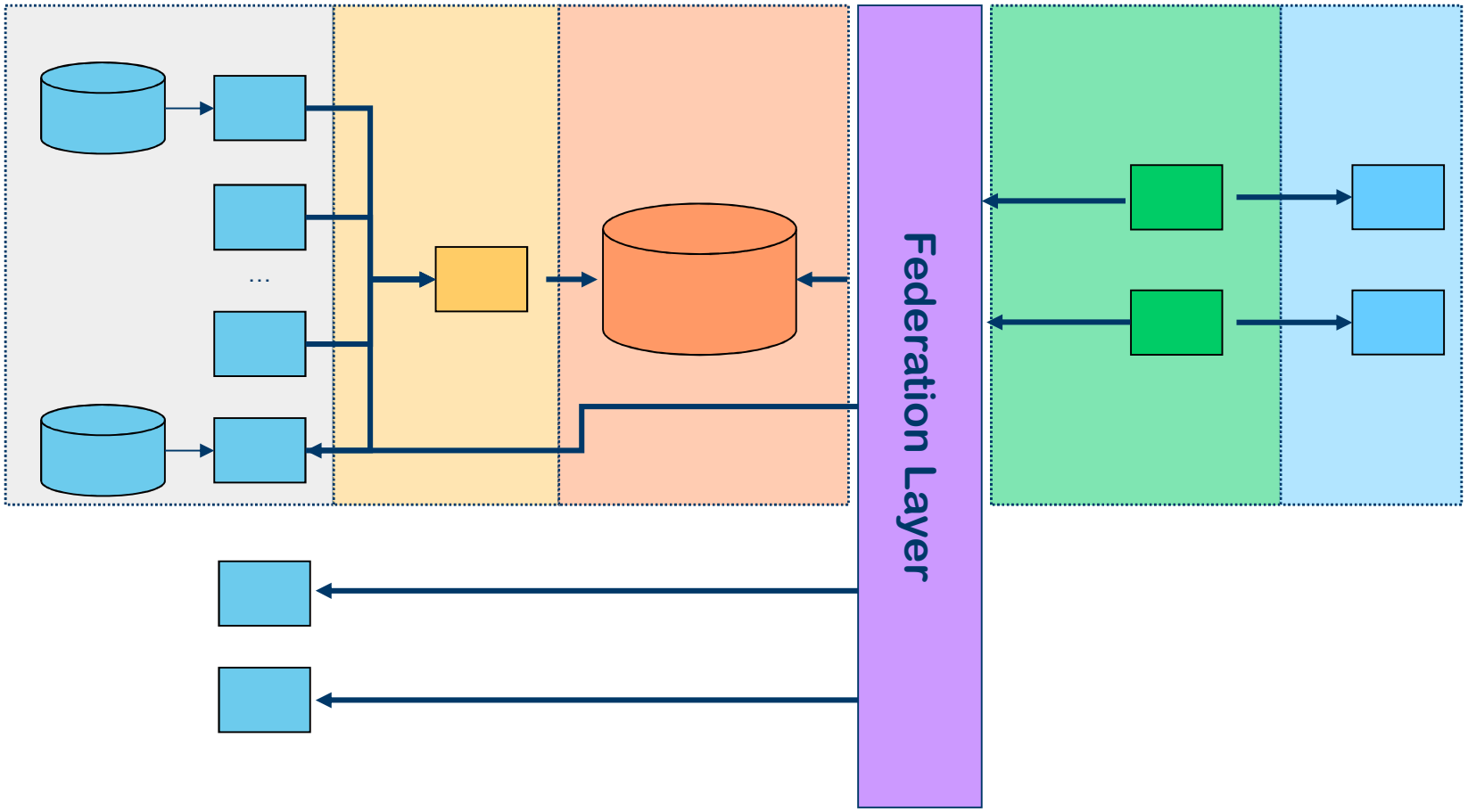
☹ complex view definitions

☺ lower storage consumption

☺ shorter processing time

☺ better time-to-market

Federated DWH-Architecture



Federated DWH-Architecture

- Access to OLTP (!) and DWH databases via federation layer

☺ short time-to-market

☺ current data (real-time view of data)

☹ additional dependencies

☹ impact on OLTP processing

☹ data are typically not historized in OLTP systems

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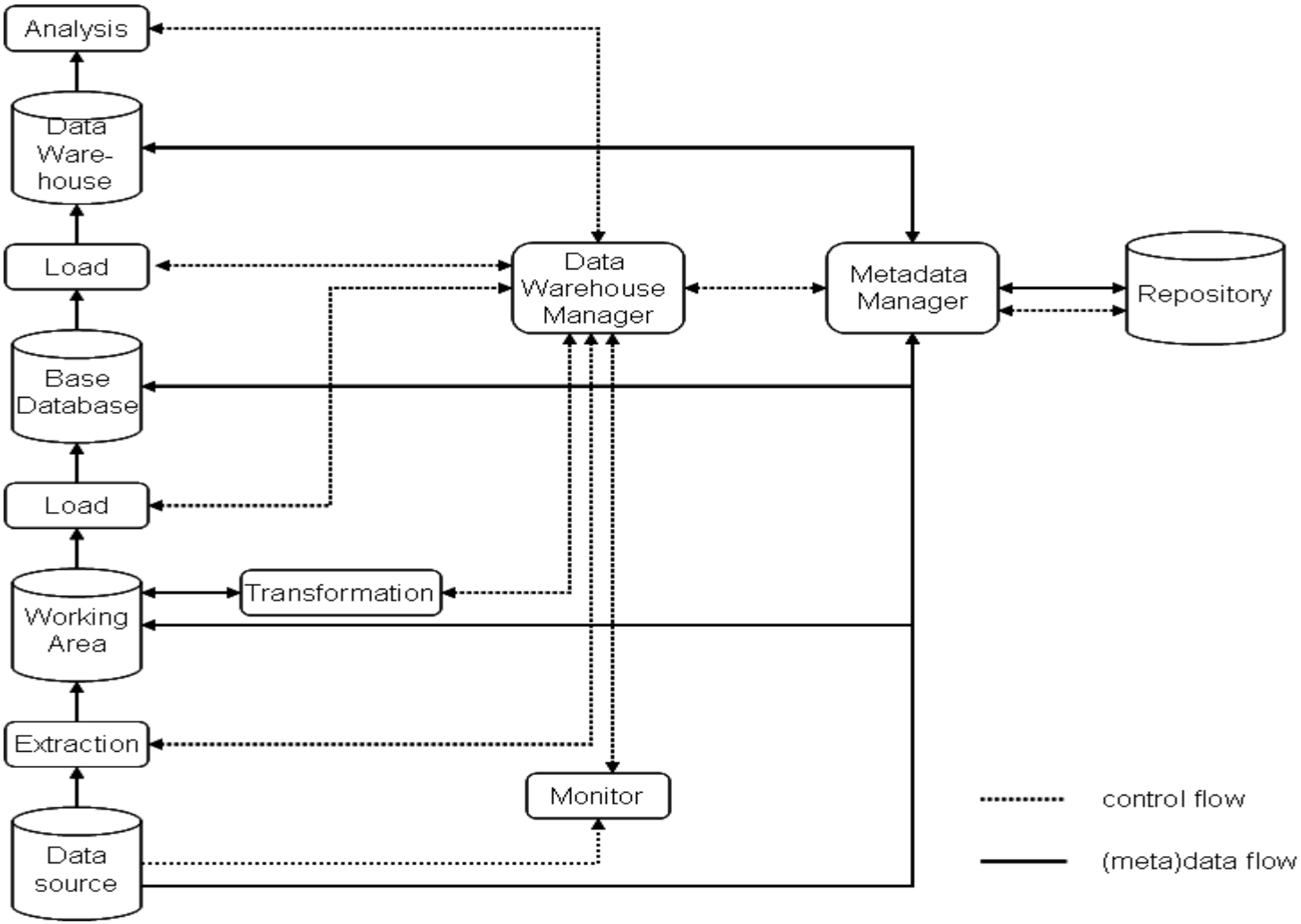
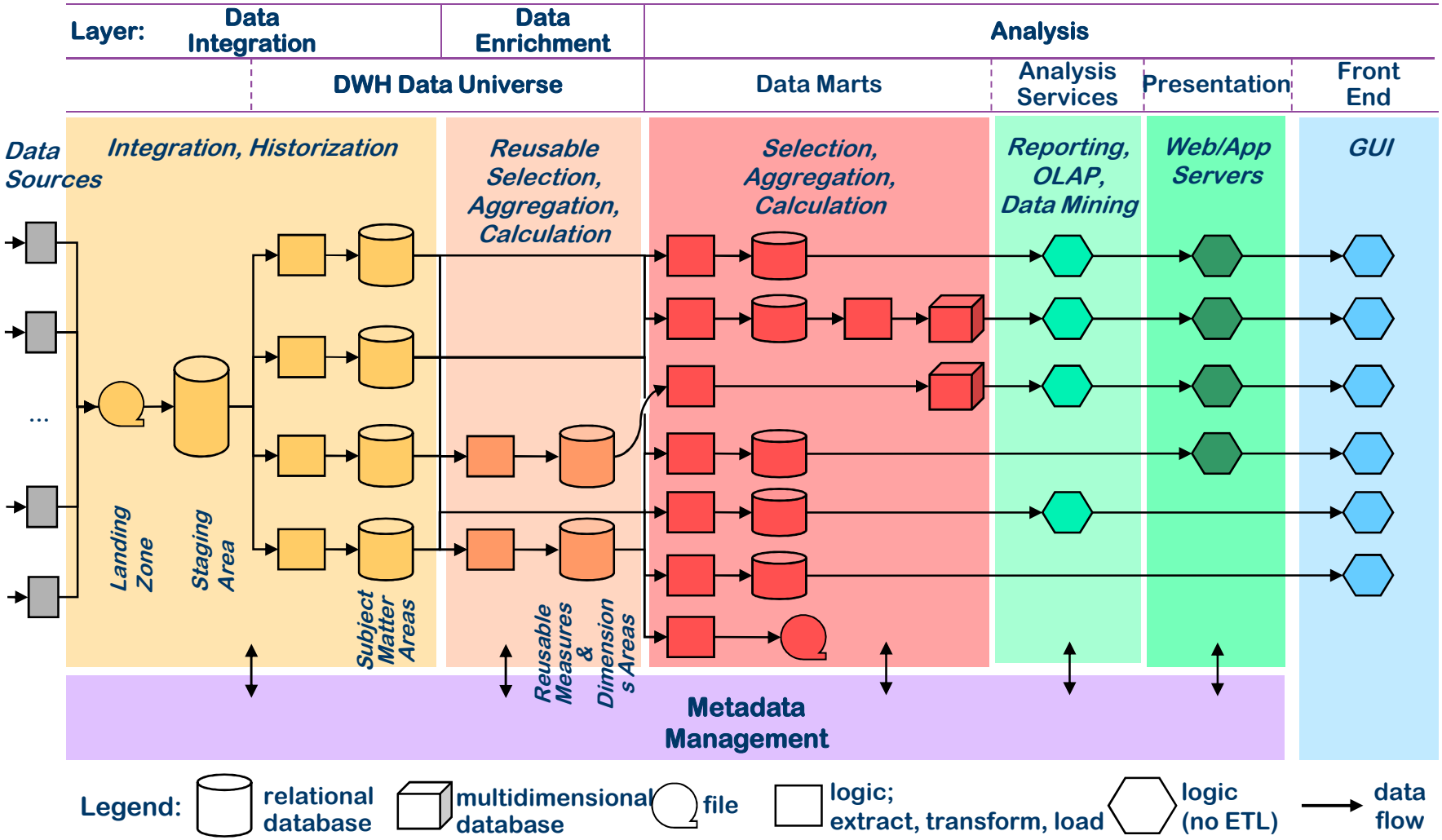
The Notion of "Reference Architecture"

- "A reference model is a division of functionality together with data flow between the pieces. A reference model is a **standard decomposition** of a known problem into parts that cooperatively solve the problem. Arising from experience, reference models are a **characteristic of mature domains**." [Bass et al., Software Architecture in Practice]
- "A reference architecture is a reference model mapped onto software elements (that cooperatively implement the functionality defined in the reference model) and the data flows between them." [Bass et al., Software Architecture in Practice]

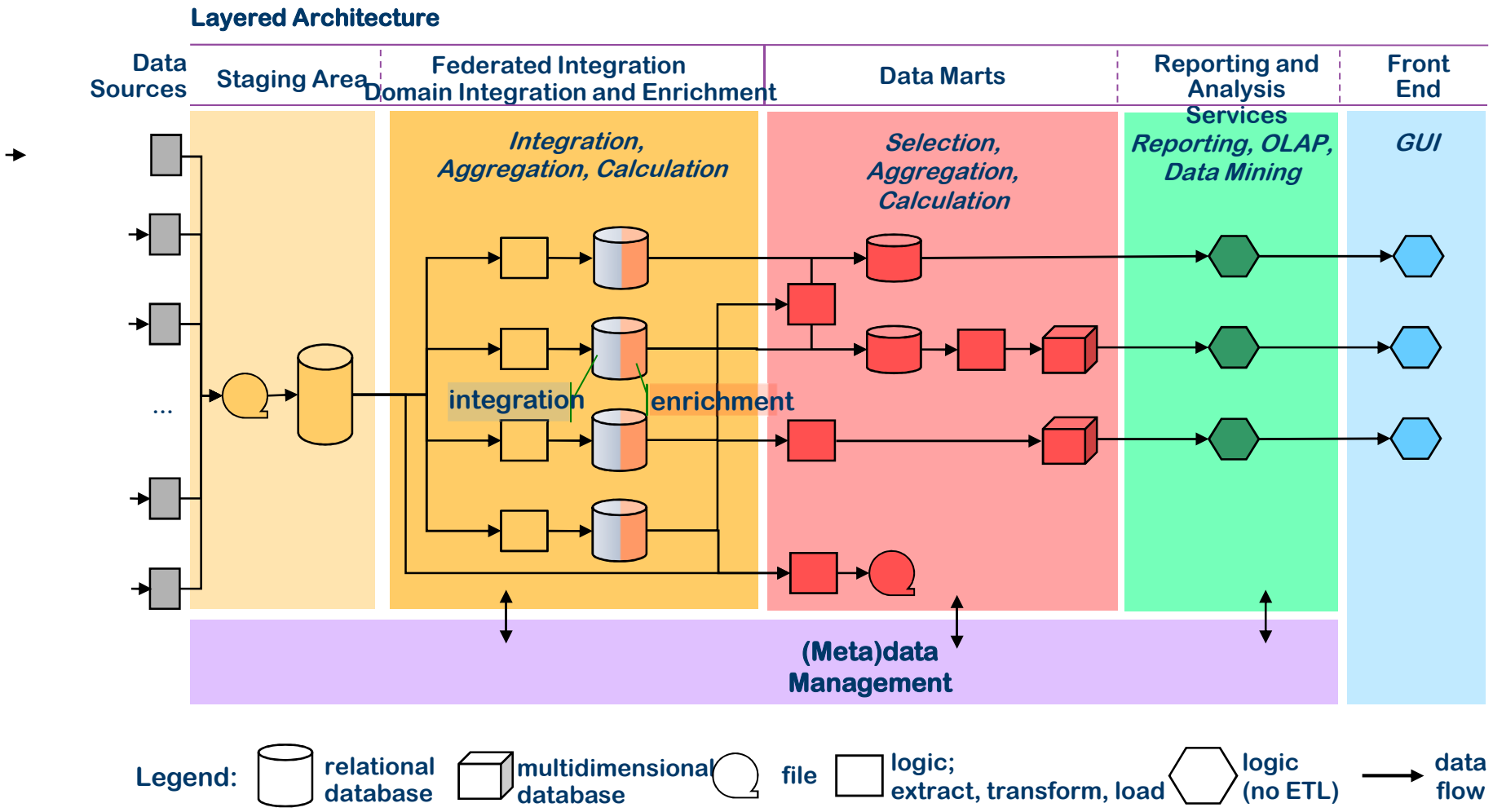
Reference Architecture in [Bauer & Günzel 2000]



Credit Suisse DWH Reference Architecture V4



Credit Suisse DWH Reference Architecture V5



Credit Suisse Reference Architecture: Principles

general principles	P1: Separation of integration and analysis P2: Ownership of DWH-applications P3: Managed data quality P4: Corrections and adjustments P5: Encapsulation of data access across layers
data integration principles	P6: Logical integration of base data into centrally-managed schemas
data enrichment principles	P7: Reusable complex logic in enrichment applications P8: Independence of enrichment applications
analysis principles	P9: Independence of data marts P10: Private data marts

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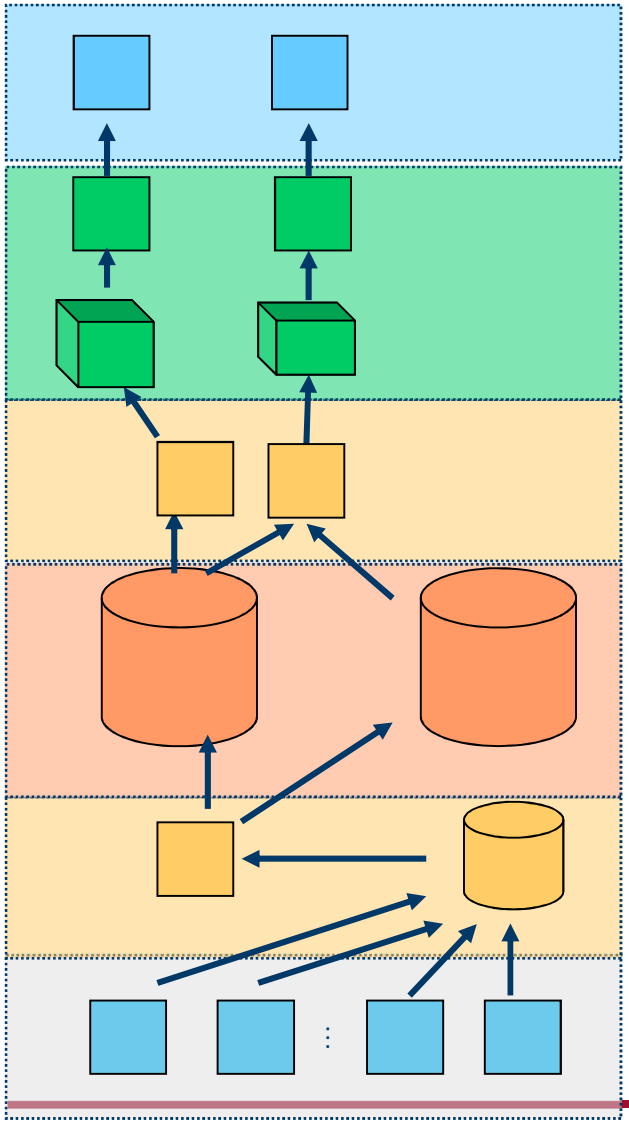
Application Platforms - Definition

Application Platform (AP): Set of integrated **technical components** and **processes** for the **development** and **operation** of similar applications

- Frees developers and operations from many infrastructure and operation concerns
- Focuses on efficient processes and lean operation
- Developing an AP is substantially more expensive than building the infrastructure for a single application. An adequate number of applications sharing the platform is necessary to amortize the effort
- An AP is designed and supported as a whole (allows optimizations not possible on a per component basis, e.g. availability, BCP, security, audit)
- Standard products, processes, and guidelines
  - HW, OS, middleware, network for test levels and production
  - System Management (deployment, change, monitoring, administration, …)
  - Security (authentication, authorization, encryption, firewalls, ...)
  - Development (tools, frameworks, construction guidelines, …)
  - Overall platform support, release management & roadmap, security concept, operating manual, usage criteria
  - Cross-AP communication via integration infrastructure

DWH-Platforms



- Standard components, especially
  - DBMS
  - ETL-Tool
  - BI-Suite
- Integration of these components
  - Which each other
  - Into security infrastructure
  - into Systems Management (e.g. monitoring)
- Architecture- and development standards and guidelines
  - Reference architecture
  - Detail concepts (e.g., metadata, data quality)
  - Modeling guidelines

Conclusion

- Different architecture styles exist
- There is no universally best solution
  - Best architecture depends on scope and role of the DWH as well as on the maturity of the organization
- Architecture and concept are critical especially for enterprise DWHs
- Reference architectures are useful as blueprints and for the enforcement of standards
- Big, enterprise-wide DWHs tend to have two or even three layers
- (Application) Platforms are an approach to industrialize and standardize, which is particularly important in the DWH area (**why** ?)