

A12

LOW CODE FOR CUSTOM ENTERPRISE SOFTWARE

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01

Executive Summary

A12 is an Enterprise Low Code Platform for realizing enterprise applications in complex IT landscapes.

This white paper presents the A12 approach and demonstrates how it can be used to turn applications into fully integrated enterprise applications that will work for a long time to come.

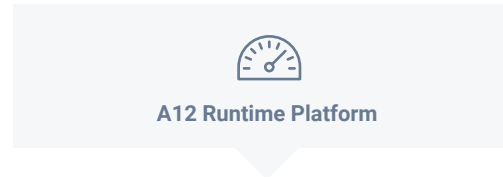
1. Executive Summary

Structure of the A12 Platform



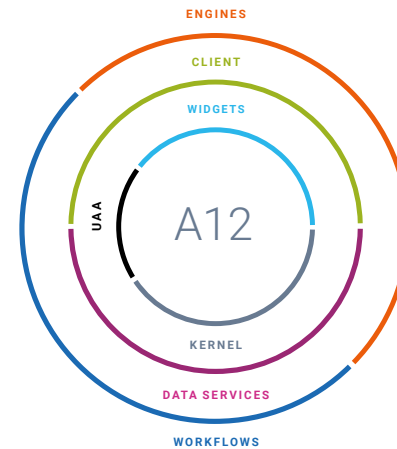
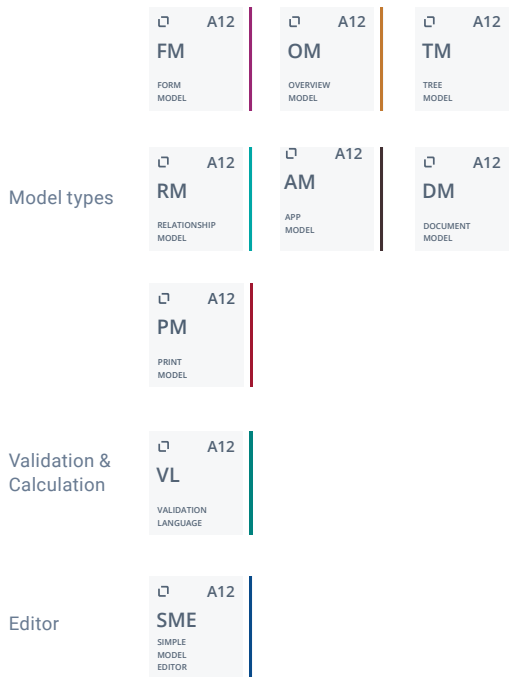
A12 Modeling Platform

A12's **modeling platform** provides tools to quickly create and maintain parts of an application without programming skills.



A12 Runtime Platform

A12's **runtime platform** provides the flexibility to develop low code applications in combination with professional custom software development and system integration which evolve into fully integrated enterprise applications.



Modular, flexibly applicable client- and server-side components in a modern enterprise architecture

For Which Operational Scenarios Is A12 Designed?

A12 is intended for professional custom software development projects. It is aimed at large and medium-sized companies, and public authorities that need highly scalable, secure, robust, and potentially business-critical web applications.

This includes form-based applications, portals and administrative processes for the public sector, underwriting platforms for industrial insurance, and integrated solutions for online, retail and mail order businesses (Multi-Channel).

Using A12 is particularly beneficial in overarching scenarios. The model-driven approach makes it possible to use the modelled business expertise across all applications. This ensures consistency, prevents duplication, simplifies release and dependency management and reduces testing overhead.

1. Executive Summary

What Benefits Does A12 Provide?



1

Handling your business content yourself

Business experts and analysts can use the modeling tools themselves to create the software's domain-specific core and maintain it in the long term.

- Adjust business aspects without programming knowledge
- Implement business changes rapidly
- Automate the software development process extensively



2

An open platform, not a closed ecosystem

A12 is designed as an open system. It provides an enormous amount of flexibility for software development, long-term maintenance and further development.

- Flexible use of modular runtime components
- Systematic use of open source technology
- APIs for individual extensions at any level
- Full operational control – on-premises or (private) cloud-based
- Requirements can be entered directly into the A12 base



3

Future-proof platform for long-lasting software

The consistent separation of business-specific models and technology makes it possible to retain the business-specific core even in the case of technological leaps.

- Detached innovation of technology through model-based approach
- "Data First" principle for sustainable domain-oriented modeling
- Careful technology selection and use of industry standards
- Continuous development of the technical basis



02

Motivation and Approach

mgm's goal is to faster and more economically build enterprise software that is robust, secure and durable. Our experienced software engineers back up this claim. They work at gradually reducing the typical expenditure involved in developing enterprise applications. This is first and foremost done by using model-driven abstractions and separating business expertise and technology.

2. Motivation and Approach

From Micro Apps to Integrated Enterprise Applications

Many enterprise applications generally originate as pragmatic makeshift solutions in separate business departments. More often than not, they start off as small Excel tables. They get bigger and bigger, incorporate macros and end up becoming almost like applications themselves! This pragmatic approach (“shadow IT”) has its downsides, namely major data protection and IT security risks.

Low code platforms aim to eliminate the potential

breaches caused by makeshift solutions with applications. They give business departments the opportunity to build their own real applications, taking into account company-specific IT guidelines. This step is perfect for those makeshift solutions that have particular potential. Another challenge arises for another subset of micro apps, of course, usually for the ones that are most critical to business: they must be integrated into a heterogeneous IT landscape. Most low code platforms come with turnkey solutions for the

most common integration scenarios. But they do have their limits. Custom development and professional system integration are unavoidable.

A12 not only helps you with the transition to micro applications, but also with moving towards integrated enterprise applications. In the long term, this is where companies spend the most money: in the development, maintenance and operation of enterprise applications.

The True Cost of Enterprise Software Development

mgm has been developing custom enterprise software for over 25 years. The core concept behind A12 is based on a series of observations that we made over and over on a wide variety of projects. Most importantly, the usual cost drivers (business adjustments and integrations) that occur once a project has been started are constantly underestimated and can end up being the reason why IT projects fail over the long term, even very large ones.

Enterprise domains – anything but standard

Every enterprise software program models a certain aspect of a company's reality. The particular model is based on the enterprise domain. The enterprise domain comprises a set of (enterprise) entities. These might be things like clients, products or orders. Each of these entities is represented by an entity model in the software. This model defines the entity's structure, attributes and relationships with other entities. Entity models are subject to constant change, which is often a major cost driver in enterprise software development.

The following points are primarily responsible for change:

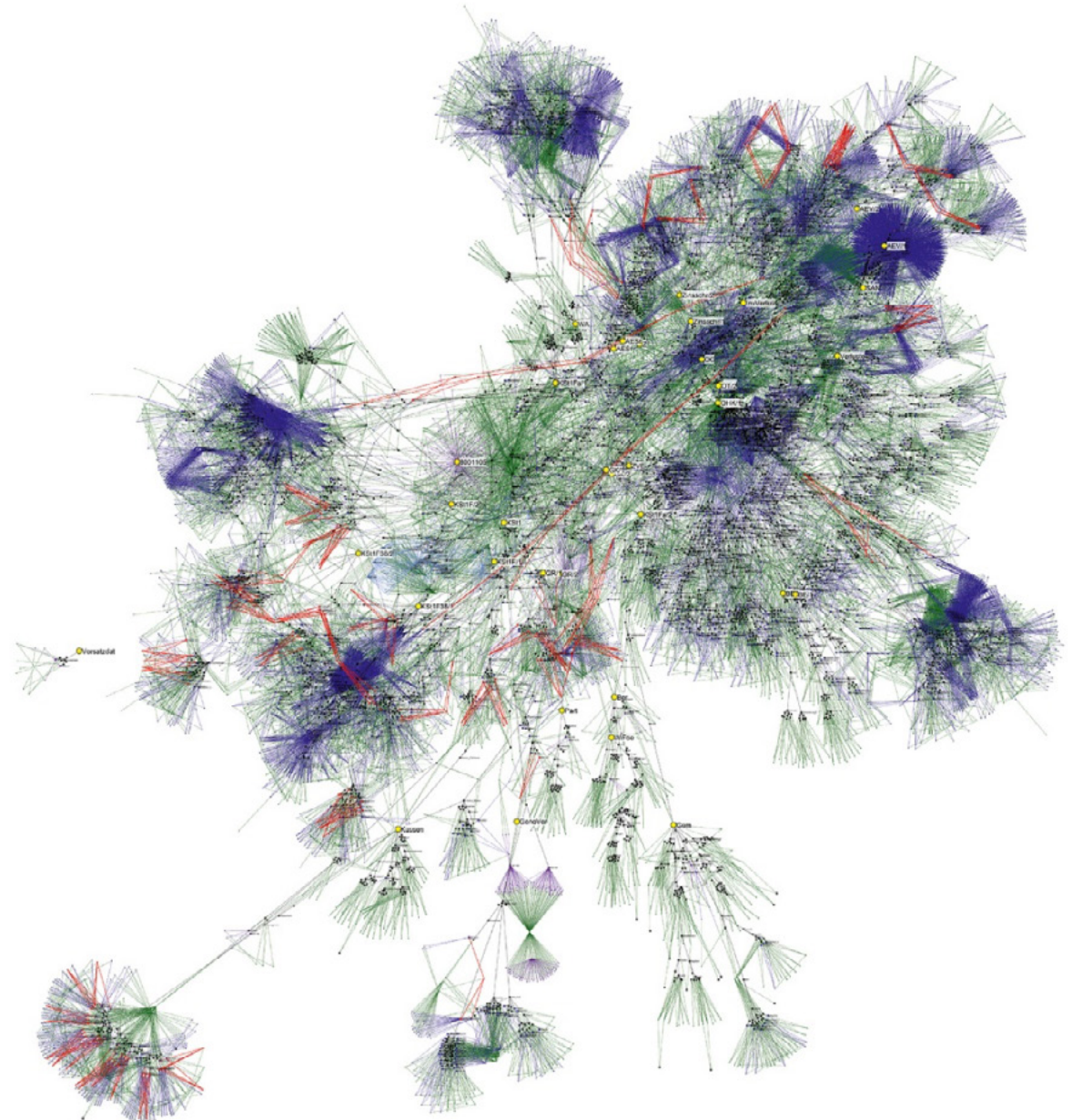
- ⊕ A growing business is a complex network. All the company knowledge is spread out in different people's brains. There are many factors that influence the business that individual company representatives deal with over and over again.
- ⊕ The company continues growing. The portfolio changes. New distribution channels are added; others are eliminated. Different branches have to adhere to new regulatory requirements.
- ⊕ Each company organises their business in their own way depending on a variety of different rules. What's more, they all use their own terminology, which is constantly growing and changing.

2. Motivation and Approach

And so, the models on which different enterprise software programs are based do not follow the same standards. On the contrary, they are highly individualised, always have exceptions and sometimes even inconsistencies.

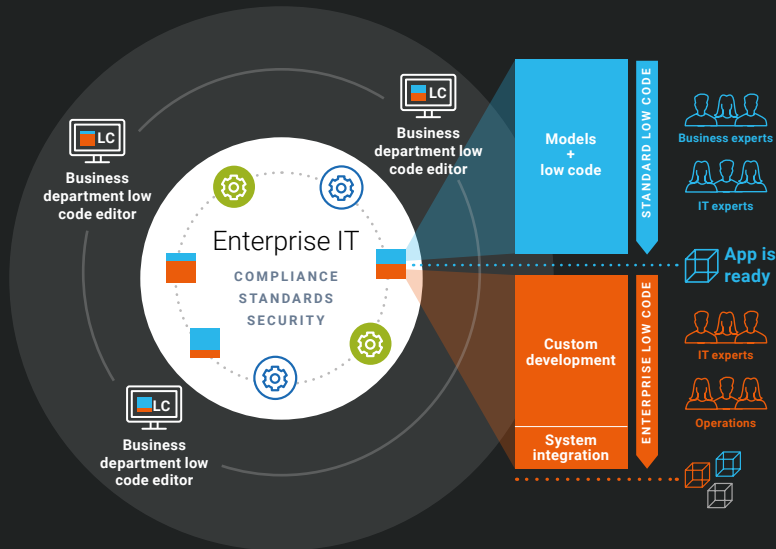
Models are yet another cost driver. Models gradually get more complex. They map aspects of reality that are constantly growing and that are relevant to the respective enterprise domain's success.

The figure illustrates just how complex they can get, for example when mapping a tax form.



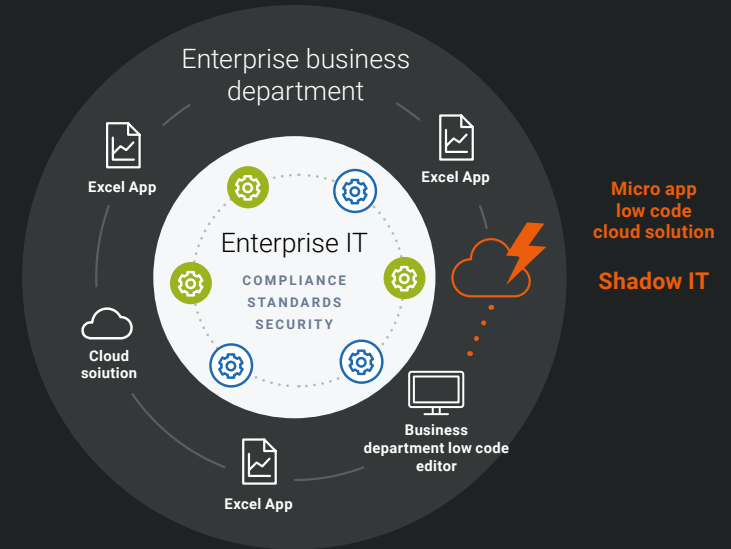
Enterprise IT and Shadow IT

Classic Enterprise IT in companies is structured centrally. The standard software and all custom-developed software used must comply with certain standards. But people are finding more and more solutions outside enterprise IT for department-specific requirements. They are created as Excel-based solutions or basic micro apps, for example. This often happens without telling the IT department. And thus shadow IT is created.



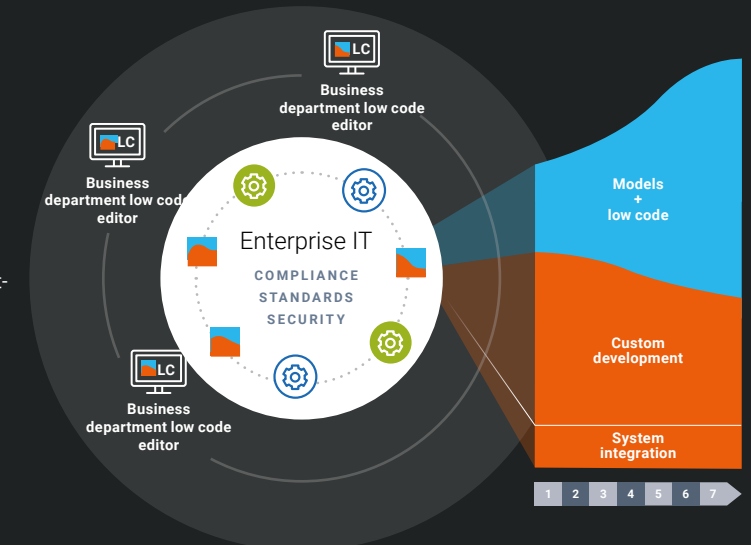
Dynamic weighting of low code and custom development

Custom Enterprise Projects require project-specific and customised methods. There can be a lot of variation in the weighting of low code and custom development from project to project. But the weighting can also vary considerably throughout the different life cycle phases of an IT project.



Enterprise low code development

If departments can design their own applications with the right low code tools and the IT department can secure the technology and standards centrally at the same time, enterprise applications with true value can be created. The low code part can be individually weighted depending on the project. The goal is to get the department and IT experts working together effectively.

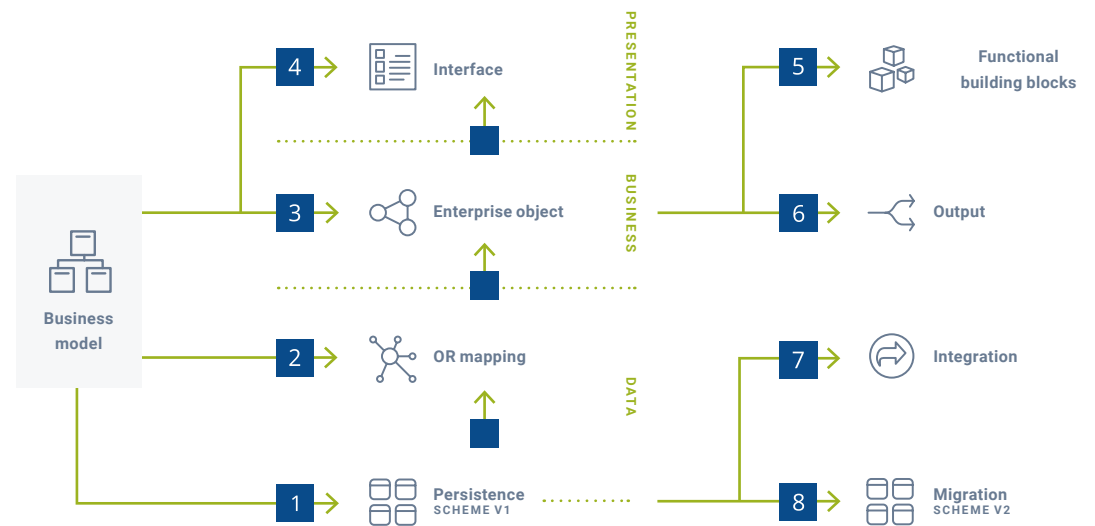


2. Motivation and Approach

Different Representations of Enterprise Entities

Any change in an enterprise entity leads to more expenditure from a software development point of view. Why? Because they have to be represented differently in different technical contexts. And you need mappings between these different representations. In practice, one tiny business change can create a domino effect of adjustments that need to be made to the software.

The figure to the right gives an overview of the various representations and mappings that are generally found in enterprise software.



The **business model** is the starting point. It is a model for implementation – the first representation of the modelled enterprise entities and their relationships to each other.

The following representations occur in a three-tier architecture:

- The enterprise objects are stored in a database in the **data tier**. Therefore, the representation needs to meet the requirements of this persistence level (1). The data is presented in tabular form in a relational database. Object-relational mapping is required so that the table data can be processed in an object-oriented high-level language like Java (2).

- The application logic is stored in the business tier. It has its own representation (3), which results from the respective processing of the enterprise objects, components and workflows.

- The **presentation tier** requires yet another representation (4). This deals with how the enterprise entities are presented in the user interface and how you can interact with them.

In addition, further representations and mappings of the enterprise entities are necessary in the following contexts:

- **Providing services for specific functionalities** – for example, checking stock (5).
- **Generating Word or PDF documents** such as insurance policies and administrative notices (6).
- **Integrating the application into other systems** in the company's IT infrastructure (7).
- **Extensive migrations**, that become necessary due to further developments of the schema of the underlying database (8).



2. Motivation and Approach



Each of these representations comes with its own set of challenges and costs. Some of them only become apparent after a while.

For example, the figure shows the fact that enterprise applications do not usually stand alone. And when they do, it's usually not for long.

On the contrary, they are usually integrated into complex IT landscapes and only realise their full potential when they are linked to a range of internal and external applications.



Heterogeneous IT Landscapes

The IT landscape of medium-sized to large companies across all industries all have one thing in common. They comprise large applications such as SAP or larger custom applications with a variety of smaller ones. In a perfect world, all applications would be fully integrated with regard to their involvement in processing business transactions and data exchange. But, because the technologies used in applications are so different (SAP, Java applications, cloud-based applications, etc.), these IT landscapes are usually built on a **technological basis that remains heterogeneous**. More specifically, this means that:

- Individual applications in this landscape usually have their own project team, release cycles and technology bases.
- Different technology and architecture decisions are made for custom applications depending on the application's age and the project team's preferences and decisions. This also applies to integrated applications that are based on applications such as SAP or MS Dynamics.
- Different applications usually also have different contact persons on the business side of things. These people draft the business specifications for the application's initial and subsequent development.

The heterogeneity of the IT landscape is another cost driver that even today's low code approaches cannot completely resolve. Custom development work can be reduced, but not completely done away with. Even if enterprise applications start off small, integration issues usually arise sooner rather than later as applications can only reach their full potential if they are integrated.

2. Motivation and Approach

Model-Driven Development

The many different representations of enterprise entities in the various software tiers are major cost drivers in enterprise software development. How can the cost of mapping these representations be reduced? Model-driven software development provides an answer to this question. The idea behind it is modelling enterprise entities and their relationships to each other. These models can be defined and adjusted using specialist editing tools.

Special interpreters and code generators translate the models into the application.

The kicker is that the elaborate mapping of different representations no longer needs to be done by hand. The generators and interpreters do it. This means that business content, which is subject to constant changes in enterprise software, as previously mentioned, can be displayed in the software much more quickly and with less overhead.

Advantages of Model-Based Development



☑ On-schedule implementation

Model-based development makes it possible for IT systems to be implemented and delivered on time, even when business requirements change frequently.



☑ Simplified dependency management

Model-based overall architecture simplifies managing dependencies. This makes it possible to separate business expertise and technical framework into separate release cycles. Furthermore, business expertise can be broken down into specific models for each version and data type. Each of these models is explicitly versioned, but is not dependent on version and data type. Business changes can also go live independently of each other for each data type and version.



☑ Less testing overhead

Testing can be extremely costly for custom-developed software that is constantly being changed. Each version, data type and change must be tested separately for each product. However, model-based development reduces the need for business testing, which is limited to the models.



☑ Clear path for technical innovation

As business expertise and technology are separate, technical innovations can be made without having to consider all of the application's technical content. For example, you can roll out new technology in the user interface design and implementation, in persistence or in server processing.



2. Motivation and Approach

Digital and Data Sovereignty

As a long term partner of public administrations, we support our customers in their desire for a self-sufficient approach to software. Business departments can do this with A12; they can keep full control, even when the applications are highly complex and integrated.

Control over business expertise - technology interchangeability

The strict division between business expertise and technology provides great flexibility for further software development over the long term. The business models make up the software's core; they can also be adjusted and developed without the help of a software developer. They are available as simple, open format JSON files.

This separation of the business content makes it much easier to change the technology. This would not be the case if the business aspects were closely interwoven into the code. One particular advantage is that the code does not need to be completely rewritten with each technical innovation. It is much easier to keep the technology up to date.

Control over data

For business-critical software, it is essential that sensitive data is stored in a trustworthy, secure environment and that smooth operation is guaranteed. We know just how important it is to have control over your business; we see this over and over again with our customers in the e-commerce sector. During periods of higher demand, like around Christmas, the systems run at maximum load for a long time without any downtime. Which is why, on the one hand, software must be scalable and high performance, while on the other, sole control over the underlying infrastructure and the release stages involved is also necessary.

We offer the following options for A12 installation:

- ✔ On-premises operation in the company's own data centre
- ✔ Operation on mgm's private cloud, hosted in a German data centre
- ✔ Cloud operation with any cloud provider

03

Plasma UI/UX Design System

Enterprise applications are characterised by high information density and great complexity. Design languages such as Material Design hit their limits quickly. They cannot fully respond to some challenges, such as how to present complex tables, clearly. Or how to develop the user interface structure consistently when new information is added. This is why mgm developed A12's Plasma design system.

3. Plasma UI/UX design system

Efficient User Interfaces for Enterprise Software

Plasma comprises a variety of UI/UX components, usage patterns and design guidelines that can be used to design consistent, efficient and attractive user interfaces. And thus Plasma provides solutions for two of the main UI requirements in enterprise applications: scalability and complexity.

One of the main ideas behind Plasma is to reduce the represented information density as much as possible. Ideally, users are only presented with what they really need for the tasks at hand. They can work faster and more efficiently.

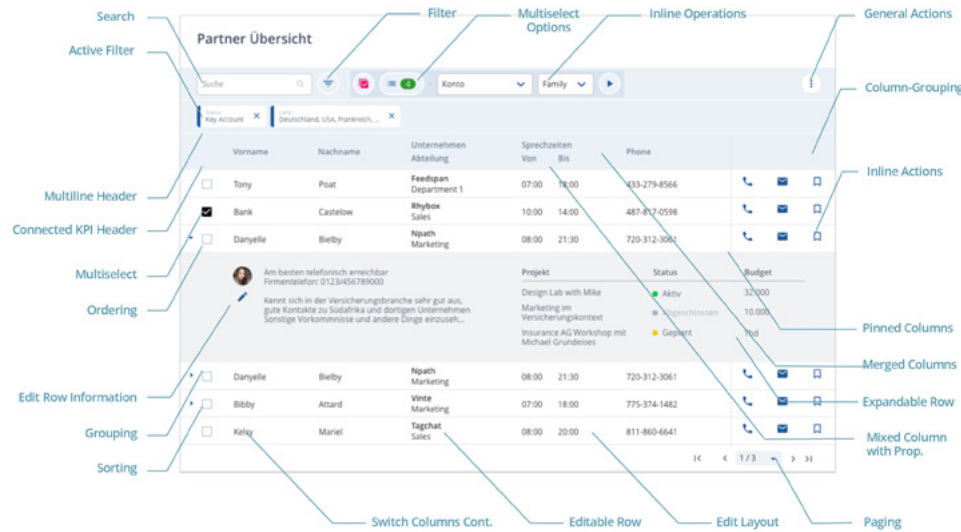
Methodology for Coherent User Experience

Plasma also has a variety of reusable models and components for requirements that appear repeatedly in enterprise application user interfaces – from log-in screens to validating user input. This includes models for the application framework, navigation elements and notifications, as well as concepts for handling enterprise objects and the standard workflows in which they are integrated.

Accessible Web Applications

The importance of accessibility in web applications is increasing. For several years now, public authorities within the EU have been obliged to make websites and mobile applications accessible. From 2025, according to the European Accessibility Act, with a few exceptions all websites and web applications must be accessible. With Plasma, the A12 platform is explicitly designed for building accessible web applications. Numerous UI components - including the model-driven engines for forms and overviews - are accessible out-of-the-box. However, in the project practice of individual software development, there are always additional aspects to consider. There are specific requirements that a Low Code platform per se cannot cover. For this purpose, the A12 team offers projects practical assistance in the form of a regularly updated guide. It contains, for example, background information on accessibility certification, design specifications, and requirements for modeling and development.

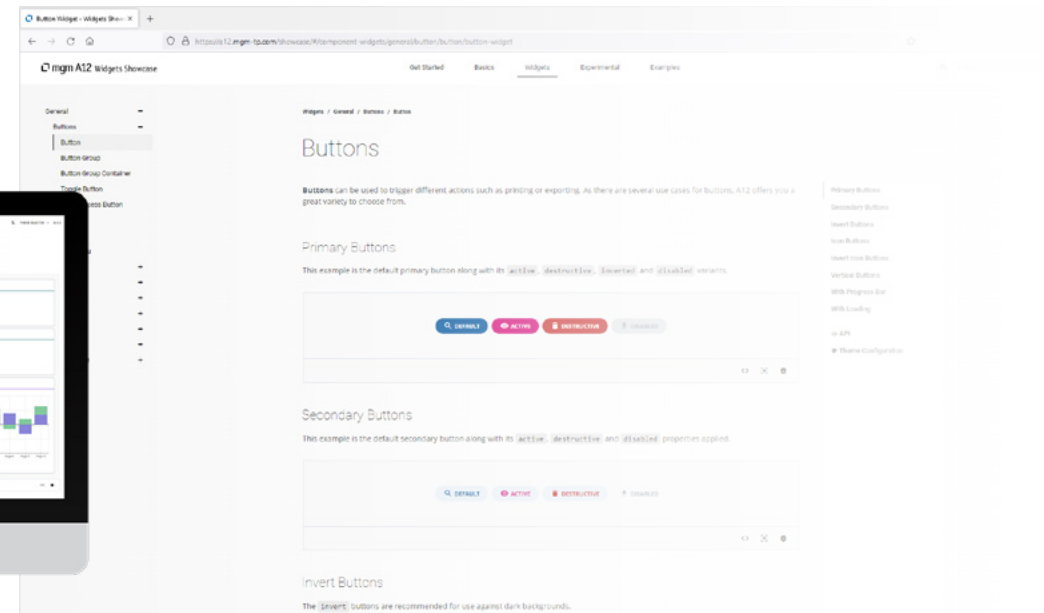
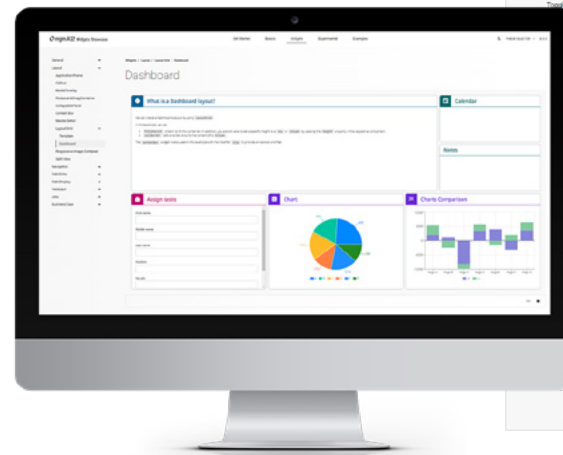
3. Plasma UI/UX design system



Unlike pure design languages like Material Design, Plasma also includes an extended range of functions which enterprise applications usually require. The figure provides an example of the overall concept for tables and all common features. We have already implemented some of these features in Plasma; others are still in progress.

A12 Widget Showcase

<https://a12.mgm-tp.com/showcase/#/>



04

Modeling Platform

The A12 modeling platform provides several modeling tools and a rule language that can be used to map high levels of business complexity for enterprise applications. The following sections provide a brief introduction to the modeling philosophy of A12 and introduce the main models and tools.

4. Modeling Platform

Modeling: A New Software Development Discipline?

The first step in the traditional development process involves business analysts and the business department working together to draft the requirements for the software to be developed. Then, they describe the requirements in prose and give them to the development team. We still use this traditional requirements analysis form for projects that are based on A12 – albeit to a lesser extent. But there is also another role: business analysts and experts can use modeling tools to design and adjust large parts of the application independently. They get much more creative leeway and **become Co-Developers/Citizen Developers**. The adjacent figure illustrates the differences between the two approaches.

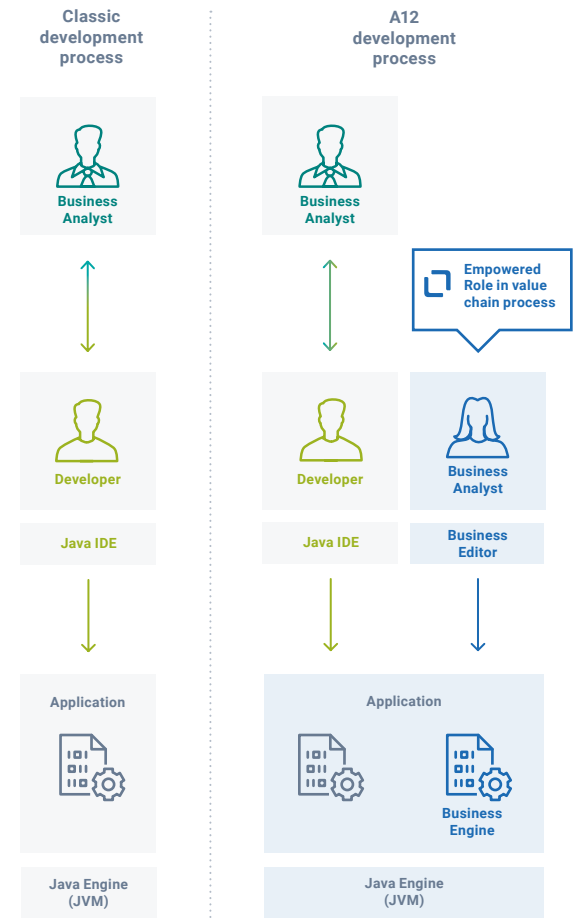
In most projects, mgm provides business analysts as part of the development team. This is beneficial as they are already familiar with the modeling tools and techniques. Customer-side business experts are usually involved from the beginning of the project. After an introduction to the modeling tools, they are then in a position to adjust essential parts of the application on their own.

The Modeling Concept of A12

The modeling approach of A12 differs in one essential point from the modeling approaches of other low code platforms: A12 follows the “data first” modeling paradigm.

Instead of starting with clicking together a user interface, A12 modeling starts with the definition of business relationships.

The decisive advantage of this approach is the clear separation of the domain description from a specific application. This creates synergies through the cross-application and cross-context use of domain expertise and great flexibility for the further development and maintenance of long-lived enterprise software.

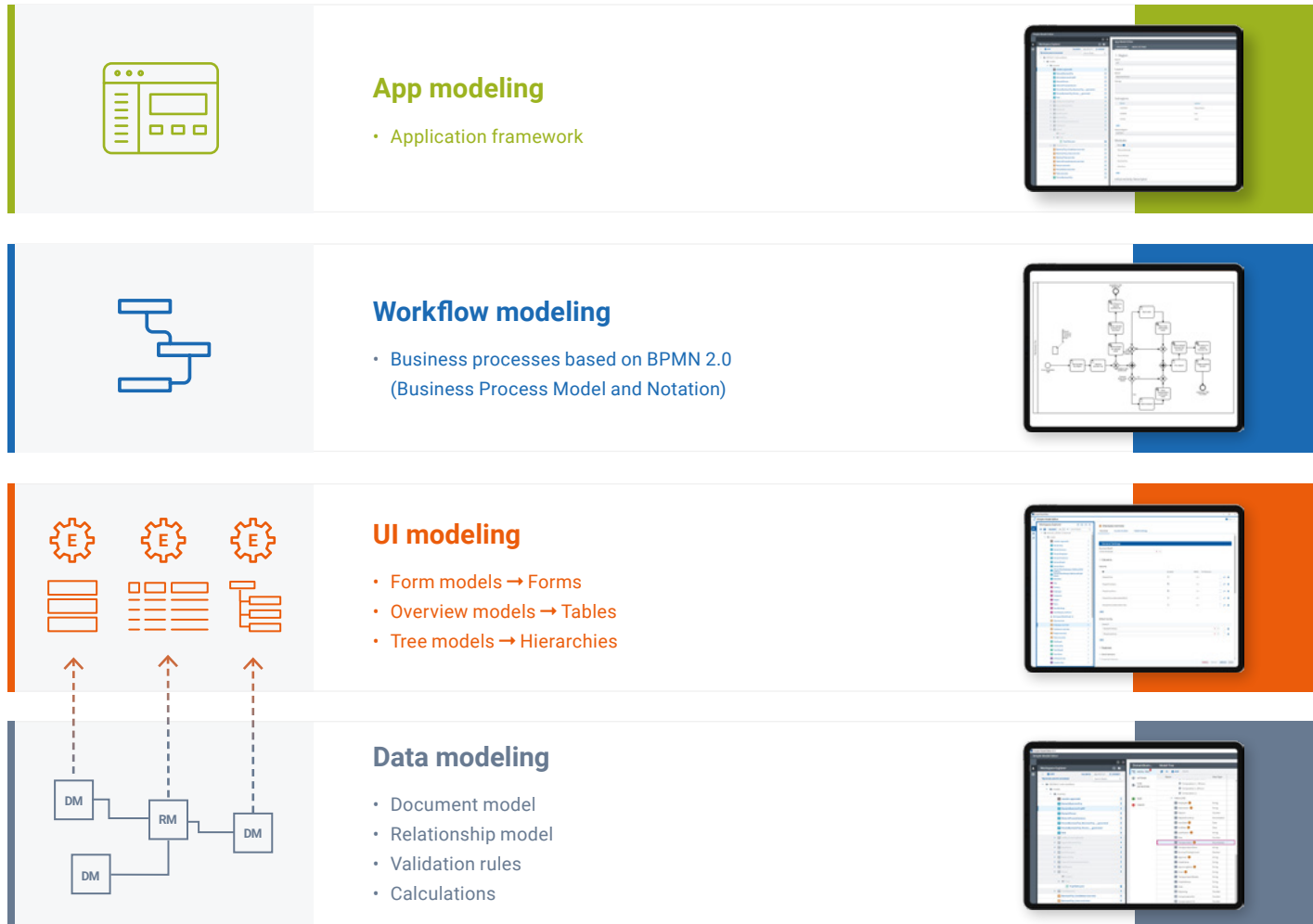


The classic role allocation is shown on the left. Role allocation in the model-based approach is shown on the right.

The business analyst helps the developer by independently designing parts of the application.

4. Modeling Platform

Main Modeling Dimensions




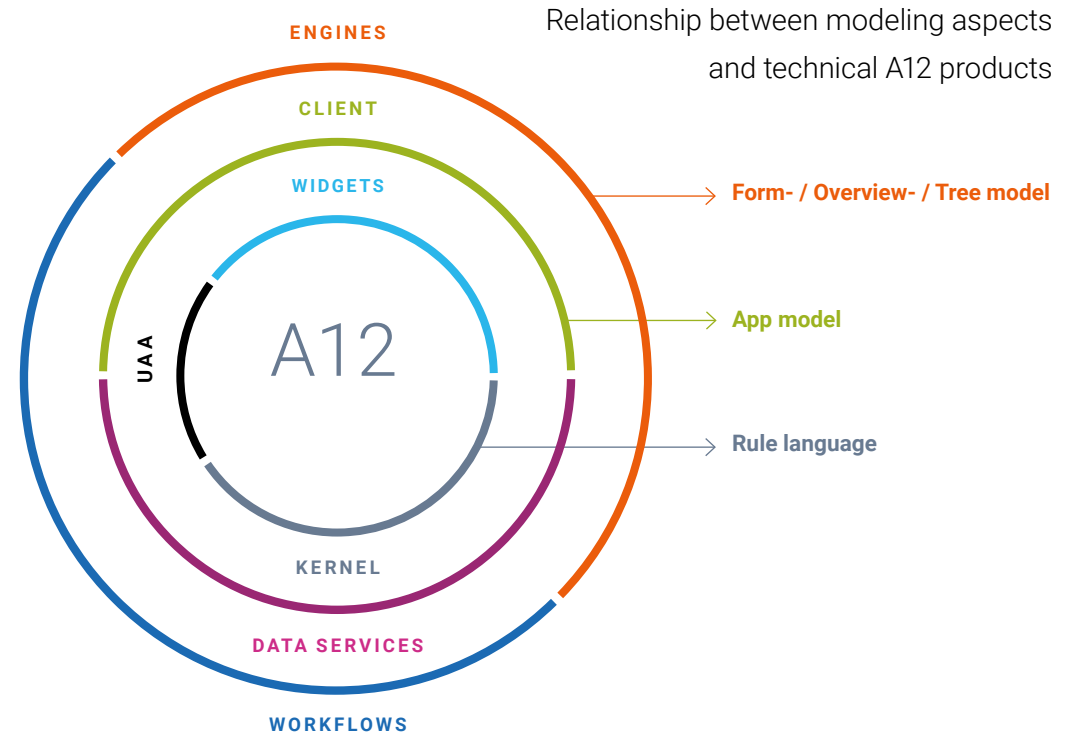
4. Modeling Platform

Modeling Business Expertise and Application Logic

Defining the enterprise entities and their relationships to each other in **data models** is an essential modeling task. Business analysts and experts can use a modeling tool to create and adjust the data structures of mapped entities, such as contracts or products. They can also use an integrated kernel language to define **validation rules** and **computations**, i.e. to map the application logic. **Relationship models** can be used to describe links between data models.

Modeling business-specific aspects keeps business expertise and technology separate from each other. Business content can be modified without any technical adjustments being needed. The technology can be developed further without all the business content having to be adjusted. We are confident that this separation of business expertise and technology will shape the future of enterprise software development. It accelerates development, prevents costly reimplementation and makes it possible to adapt to changes rapidly.

 The rule language for validations and calculations is implemented in the technical A12 component Kernel
→ see also p. 43.



¹ The term "document model" indicates that technical handling is document-oriented. In terms of content, document models describe any «entities» that can also be understood as part of a technical knowledge base.

4. Modeling Platform

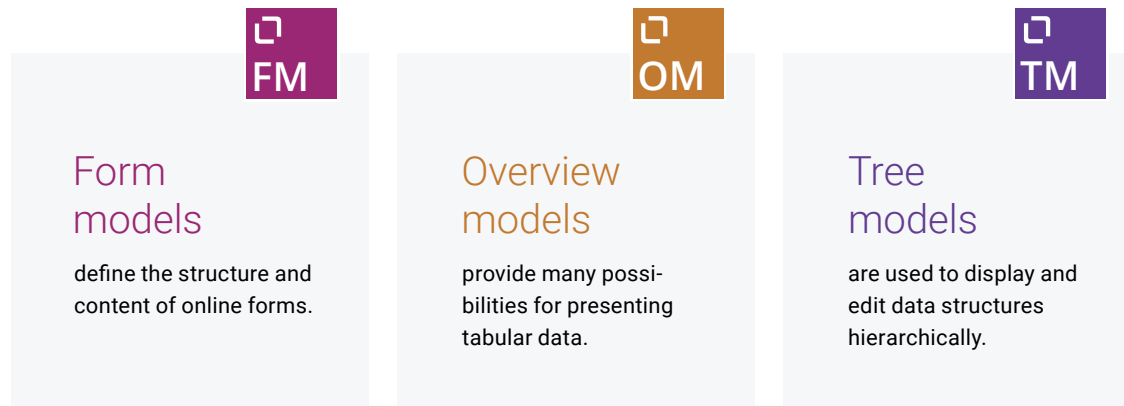
Modeling of User Interfaces

Based on the data models, business analysts are able to create specific parts of the user interfaces using A12's modeling tools.

The modeling of the user interfaces is currently limited to the areas in which model-driven components are used. A number of special UI models are available for this purpose:

For each UI model, A12 provides a corresponding engine - the Form Engine, the Overview Engine and the Tree Engine. They bring the models to life in an application.

→ Read more on p. 41.



The modeling does not follow a what-you-see-is-what-you-get principle. Instead, the models describe the underlying structures of the user interface. This has the advantage that the models are again independent of the technical implementation. The plasma design system is used for the actual representation. It ensures a coherent representation and a coherent user experience.

UI models usually refer to A12 data models. They establish connections between the fields of data models and UI elements. Let's take an input field as an example: A UI model describes its position in a form, its label, and possibly additional user instructions in a text field. A data model specifies the underlying data type and validation rules.



4. Modeling Platform

Modeling Workflows

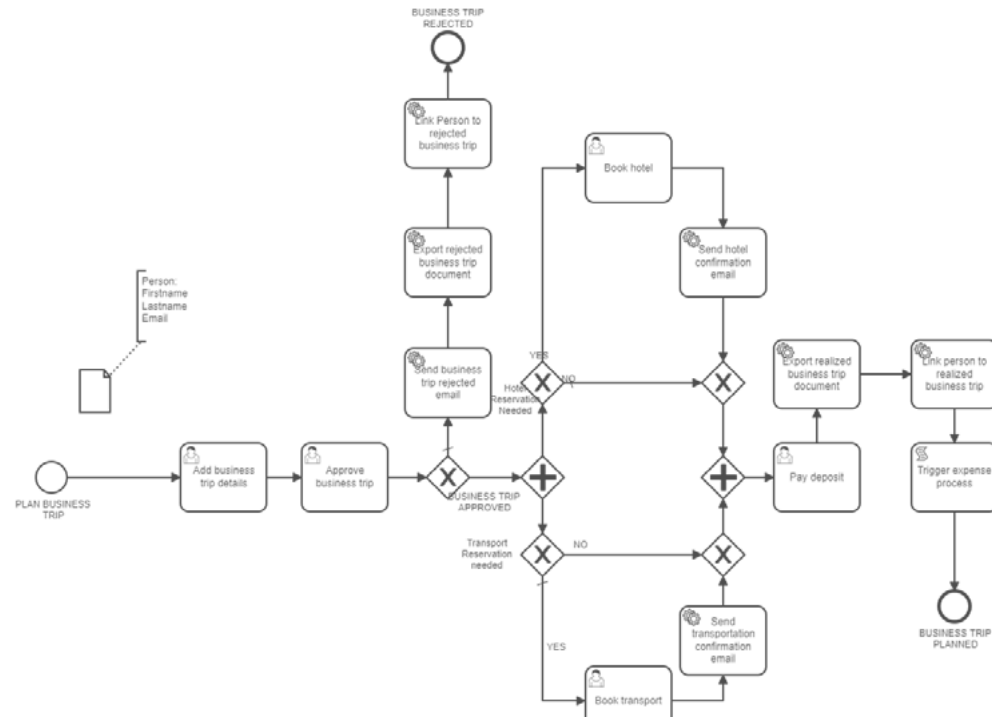
For modeling business processes, A12 relies on BPMN 2.0 (Business Process Model and Notation), an existing, established standard. The modeled business processes fit seamlessly into the modeling concept of A12. Document models describe the data used by a process. With the help of form models, the respective user tasks can be implemented in detail.

Modeling the Structure of an Application

The framework of an application can be defined with an **App Model**. It acts as a kind of container for all other models.



The app model offers configurations for certain functionalities of the technical component **Client** (see p. 42).



Modeling Print Templates

In the context of business applications, the challenge of generating PDF documents arises again and again - whether it is a contract in the insurance environment, a proof of invoice in an online marketplace or the notification of a government service. With A12's Print Engine Template Editor, print templates can be created in an editor, saved as print models and easily brought into A12 applications. The resulting PDFs are compliant

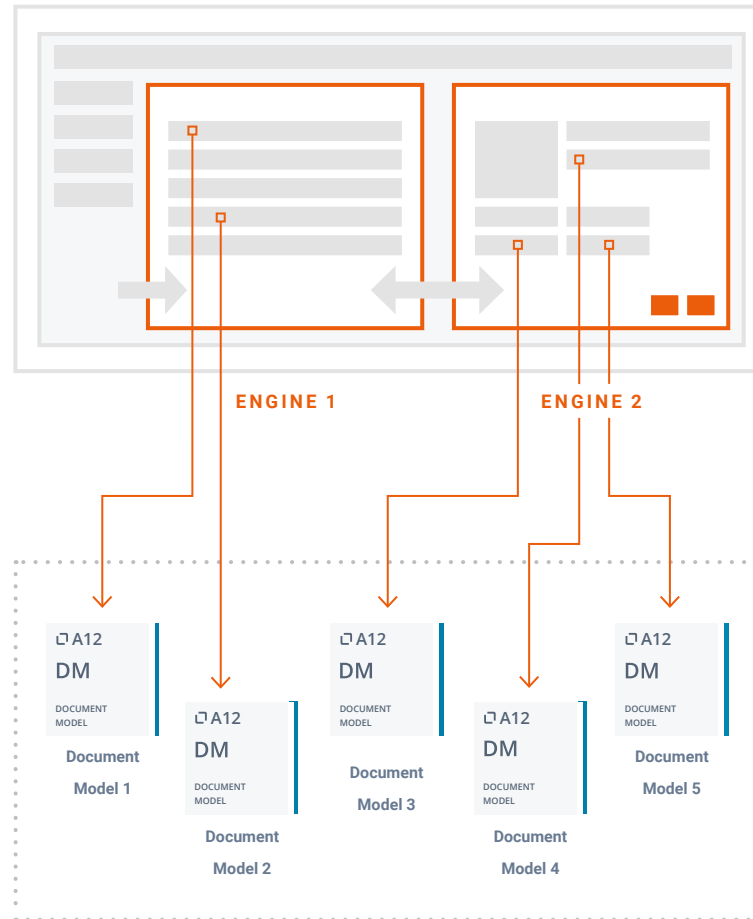
with the PDF/A standard and therefore accessible. The editor enables the convenient design of pages and sections by adding and placing individual elements such as text and images using drag & drop. Fields, calculations and tables can also be inserted directly, which refer to selected A12 document models and are filled with the corresponding stored data.

4. Modeling Platform

More Complex Modeling: Composed Document Models

With Composed Document Models (CDMs) it is possible to **use several document models in one engine** - provided that there is a relationship between the models (defined in a Relationship Model). Thanks to CDMs, a form can be fed with data defined in completely different models. The modeling concept of A12 gains significantly in flexibility and expressiveness through CDMs.

Since the release 2021.06 a first experimental version is available. It enables the definition of CDMs and CDM-based forms with the existing modeling tools, into which fields from different document models can be brought. Cross-model validation rules and calculations are supported.



4. Modeling Platform

The Model Types of A12

CATEGORY	NAME	DESCRIPTION
Data Model	Document Model	A12 document models contain field definitions and associated validation rules in a hierarchy of groups. Validation rules range from simple constraints - e.g., the definition of mandatory fields - to complex patterns and conditions across multiple fields.
	Relationship Model	Relationship models describe links between documents. They model the relationship properties and constraints.
UI Model	Form Model	Form models define the structures and contents of online forms. A12 forms consist of common UI elements such as input fields, buttons, labels, checkboxes, etc. The modeling tools provide powerful ways to organize these elements.
	Overview Model	Overview models offer various possibilities for tabular presentation of data.
	Tree Model	Tree models allow data structures to be displayed and edited hierarchically.
Workflow	BPMN 2.0	A12 supports modeling of business processes in the BPMN (Business Process Model and Notation) standard. BPMN models interact seamlessly with A12 models.
App Model	App Model	An app model defines the framework of the application and acts as a kind of container for all other models.
Output Model	Print Model	The Print Model can be used to create print templates for the generation of accessible PDFs.

4. Modeling Platform

Advantages of “Data First” Modeling With the A12 Rule Language

Business experts and analysts can create and modify domain-specific models for enterprise applications using A12’s data modeling tools. No programming knowledge necessary! Data models encapsulate the central aspects of the enterprise logic. They describe the entities with which enterprise applications operate, such as contracts and products with all their properties.

The use of data models has several advantages:

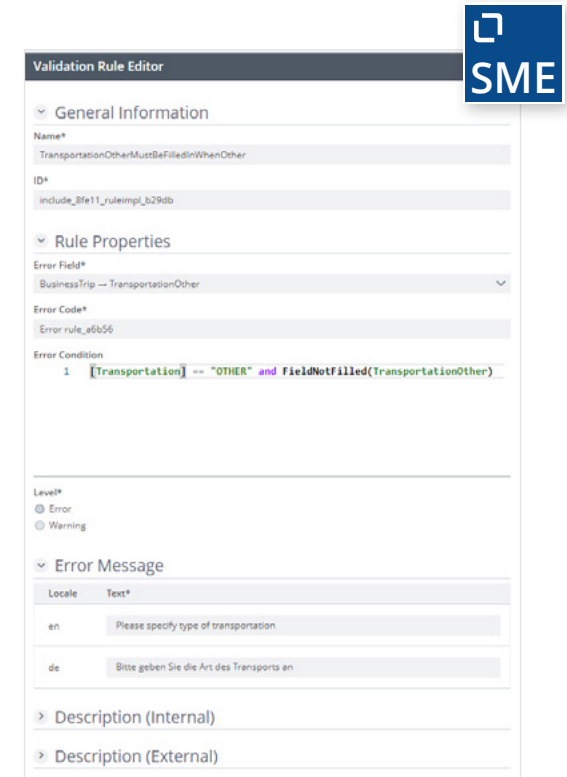
- ⊕ Reduced development costs and customisable applications
- ⊕ Business experts can modify the applications on their own. Developers are not needed to rework the implementation every single time there is a change in the enterprise domain.
- ⊕ The explicit direct storage in models makes it possible to search for and research business expertise. This also provides, for example, explicit traceability of business changes.
- ⊕ Improved reusability and independence from technologies

An important part of data modeling in A12 is the **rule language for validations and computations**. Based on business requirements, it enables the definition of rules that cover all conceivable field-related validation tasks. The most comprehensive data validation possible is crucial to avoid security risks and to ensure data integrity in business applications.

The language contains many predefined predicates. It supports nested comparisons, arithmetic operations and provides special operators for handling elements like dates. It also supports special conditions for checking in which configuration fields may or may not be specified. The various subconditions and operations can be combined.

The modeling tools for document models support the language directly. It has been successfully deployed for years in large productive software systems. Our customers use it in many projects to independently manage validation rules and computations.

The language combines the simplicity of the propositional logic with the expressiveness of the predicate logic. It is particularly well suited for forms and strong typing in business domains.



Creating a rule in SME



4. Modeling Platform

The rule language has the following key features:

- ⊕ Rule conditions describe errors – the end-user is thus shown messages related to the specific error scenario
- ⊕ Use of logical connectives ‘And’ and ‘Or’ to combine different subconditions
- ⊕ Negation operations are not used. Instead, the different predefined conditions are each provided in positive and negative form. This ensures that the subconditions are simpler and are compiled in a more uniformly structured way. This makes the rule conditions more readable and clearer.
- ⊕ Predicate logic quantifiers are not provided as formally logical parts of the language but implicitly via operations. This ensures that the conditions are based on an expert’s formulations and are therefore easier to understand.
- ⊕ The rule languages’ logic operations allow the tree and repetitive structures to be queried directly
- ⊕ Supports set and filter operations on tree structures and repetitive structures, e.g. “add up all capital gains from all equity funds”
- ⊕ Facilitate iterations via repetitive structures and shorten the control conditions
- ⊕ Computations and validations based on the same language, so the full validation language can also be used for computation preconditions. All of the language’s set and filter operations are available for formulating the computation operations and values can be computed for all predefined field types

Features:

- ☑ A powerful and versatile validation and computation language
- ☑ Auto-completion and syntax highlighting
- ☑ Predefined predicates for fields, lists of fields and groups that can be combined freely
- ☑ Arithmetic operations, comparisons, special operators for processing

MODELABLE WITH A12

Domain expertise - data models with validation rules and calculations

Frame of an application including placement of model-driven engines

Forms, including repeatable structures

Tabular overviews of data sets

Tree-like overviews of data sets

Relationships between different model-driven components

Workflows following the BPMN 2.0 standard

INDIVIDUALLY REALIZABLE

complex algorithms (e.g. generic premium calculator in the insurance environment)

placement of simple widgets

definition or adaptation of design elements

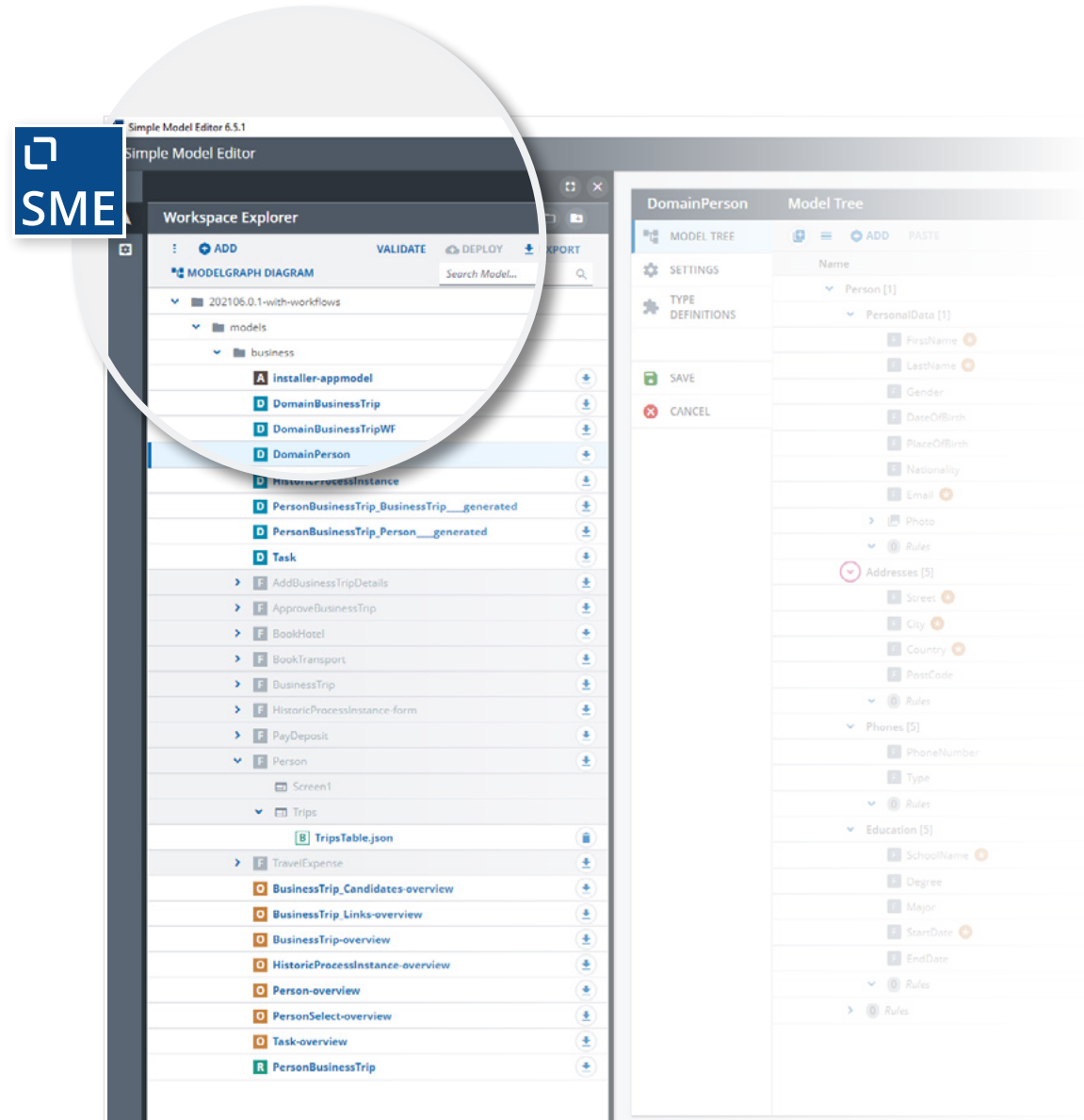
4. Modeling Platform

Modeling Tools for Data, Form and App Design

The central modeling tool of A12 is the A12 Simple Model Editor (SME). It facilitates the editing of all A12 model types.

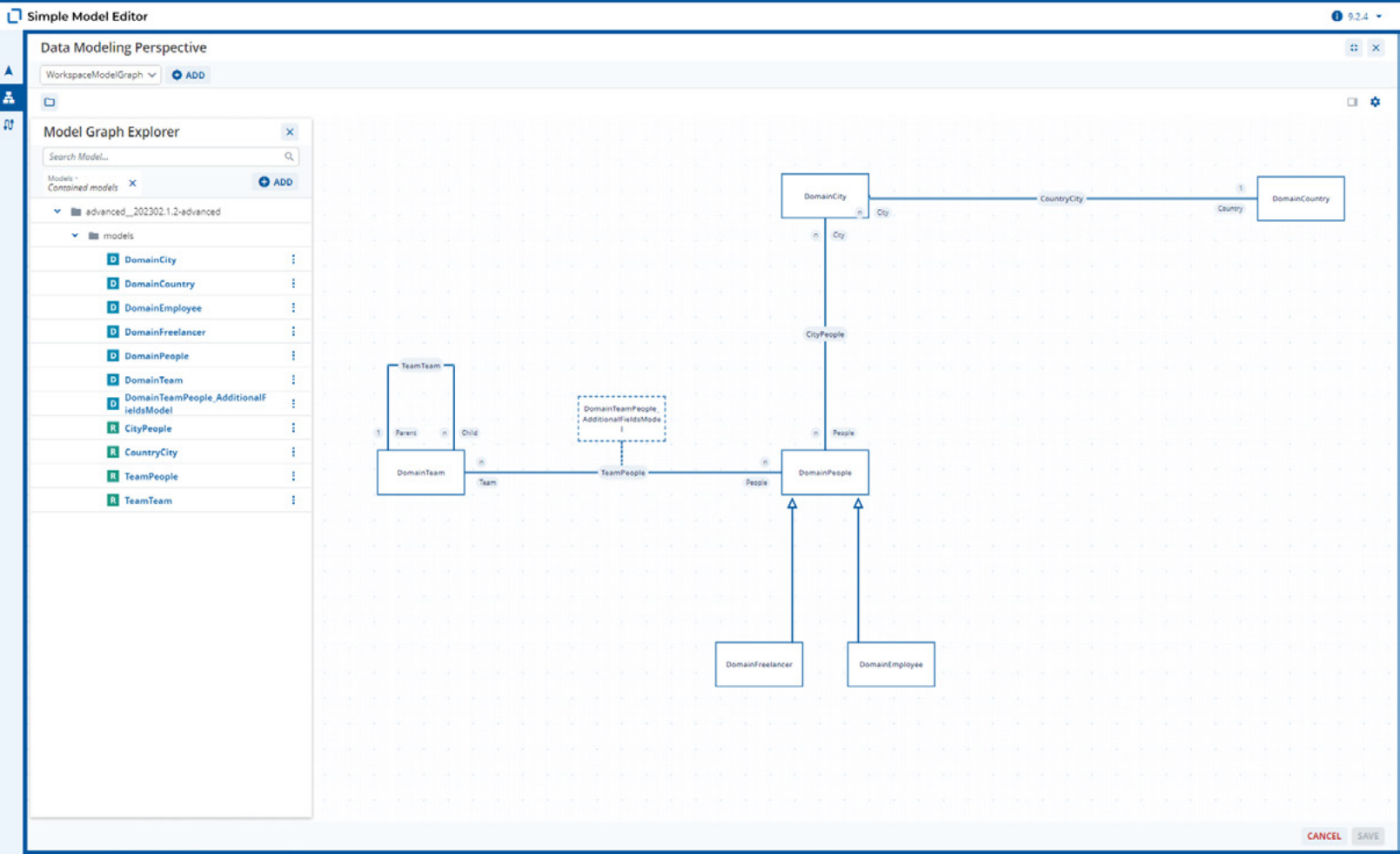
Simple Model Editor (SME)

The Simple Model Editor (SME) forms the control center for modeling in A12. A noteworthy thing about it is that the SME was built as a tool for A12 itself with A12. With the Workspace Explorer of the SME all relevant models of a project can be comfortably managed, new models can be added and existing models can be edited. The models in the workspace can be exported individually or bundled or deployed directly on a server.



4. Modeling Platform

The functional scope of the SME is continuously being developed further. In addition to textual modeling, the tool also offers visual support for modeling relationships with the Diagram Editor.



4. Modeling Platform

Installer: Using Modeling Tools Locally

To be able to use the modeling tools of A12 locally, the **A12 Installer** is available. It bundles all relevant tools in one installation file. The installer is provided with each release of A12 for Windows 10, macOS and Ubuntu Linux.

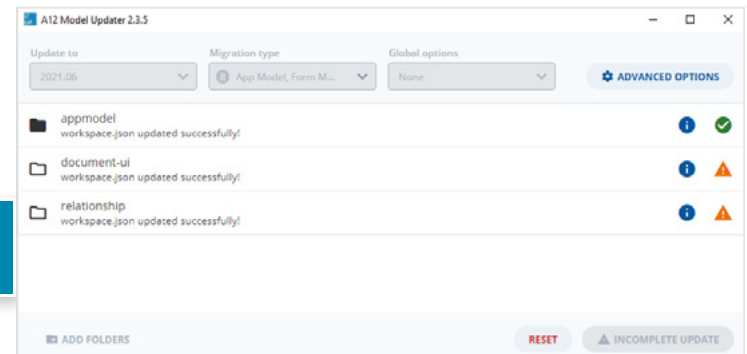
After installation, all modeling tools are ready for immediate use.

A set of included sample apps makes it easy to get started and provides a starting point for your own modeled apps. With the help of the included Preview App Control, modeled programs (preview apps) can be executed locally in the browser. The Model Updater enables convenient migration of models based on older A12 versions.

PARTS OF THE INSTALLER	DESCRIPTION
Simple Model Editor (SME)	Modular tool that bundles numerous modeling functionalities of A12
Camunda Modeler	Tool for modeling workflows
Preview App Control	Application for running A12 applications in the browser
Model Updater	Migration tool for updating existing, older A12 models
Workspaces	Sample applications (preview apps) that demonstrate the modeling scope
Dokumentation	Reference to existing online documentation, which can optionally be installed locally as well

The version number of the installer corresponds to the version number of the overall release.

With the help of the Model Updater, existing models can be easily migrated to the latest version.



05

Runtime Platform

The A12 runtime platform consists of a set of modular client and server side components in a modern enterprise architecture. It provides robust components for typical enterprise application requirements.

At the same time, it gives the development team full control through fine-grained entry points to plug in their own code and implement individual project requirements.

5. Runtime Platform

A Different Range of Tasks for Developers

The model-driven approach also comes with a variety of changes for developers, too. They are no longer solely responsible for building the whole application. Their workload is smaller, especially in relation to handling business changes. The application can be compared to a play; the models designed by the business analysts are like the protagonists in the limelight. The developers, however, make it possible for the play to be performed at all. They prepare the stage and make sure that the protagonists are shown in the best light.

Modeled business expertise reduces workload

In a conventional software project, the development team is responsible for coding the whole application on their own. To do this, the team must understand the idea behind the application down to the smallest detail. But that's a massive challenge for highly complex application fields, such as taxation or industrial insurance.

The model-driven approach changes this situation. Business analysts and experts map the business logic in models and put them directly into the software.

This greatly lessens the developers' load. They no longer need to understand the modeled business aspects nor implement it by hand. The focus of the work shifts.

Connecting, maintaining and extending the application platform

Projects based on A12 do not start off as greenfield projects. They build on an existing foundation. This foundation isn't static; it's being constantly developed. One of the main things that the developers have to do is to connect the foundation (the project's A12 application platform), maintain it and, if necessary, extend it individually. The Technical Professional Services Team provides support.

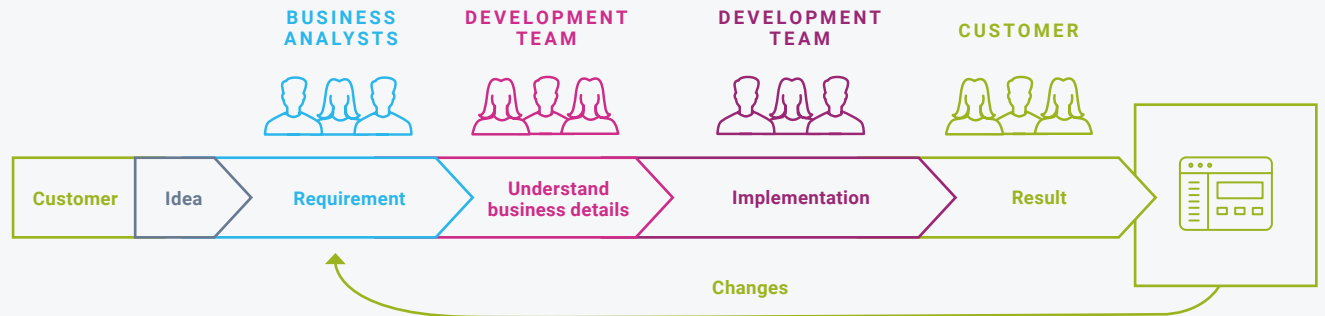
More complex functions and integration work

Developers also write code that implements more complex functions. An example of this is a complex computation that goes beyond the existing scope of the modelling tools. Furthermore, one task still left to the developers is to integrate the application into the existing heterogeneous IT landscape.

5. Runtime Platform

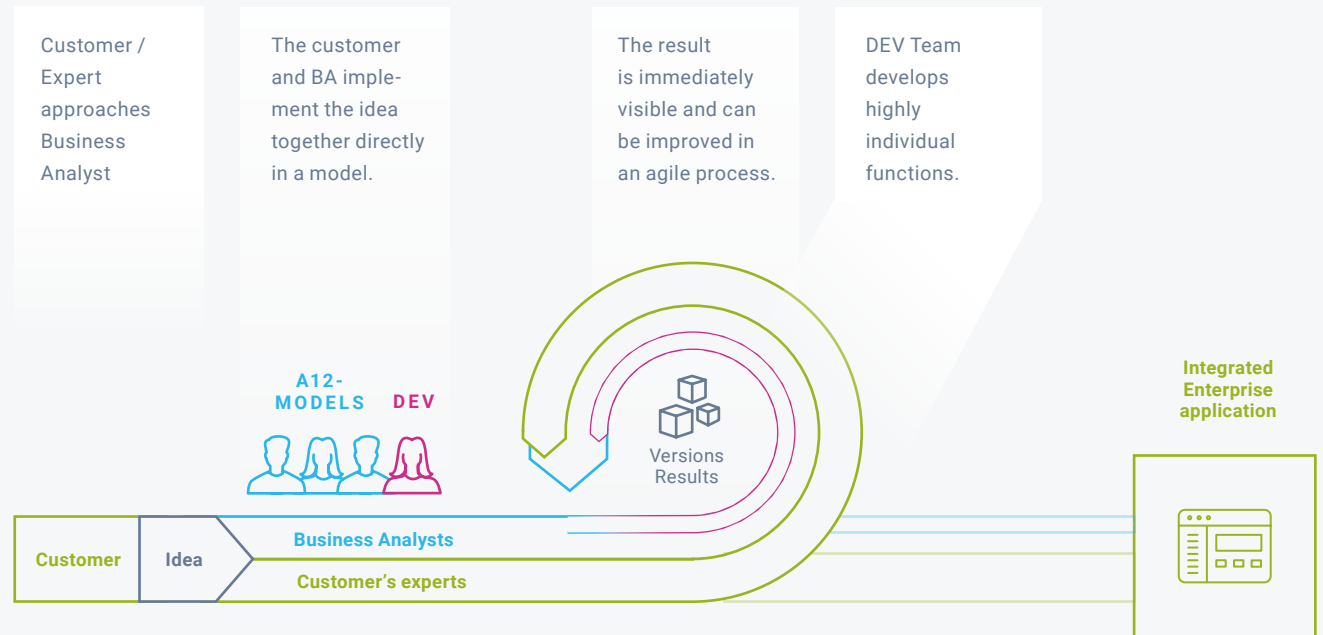
Traditional Approach vs. Model-Based Approach

Traditional approach



Model-based approach

- ☑ Requirements in Models
- ☑ Develop together
- ☑ Result visible immediately
- ☑ Agile and fast



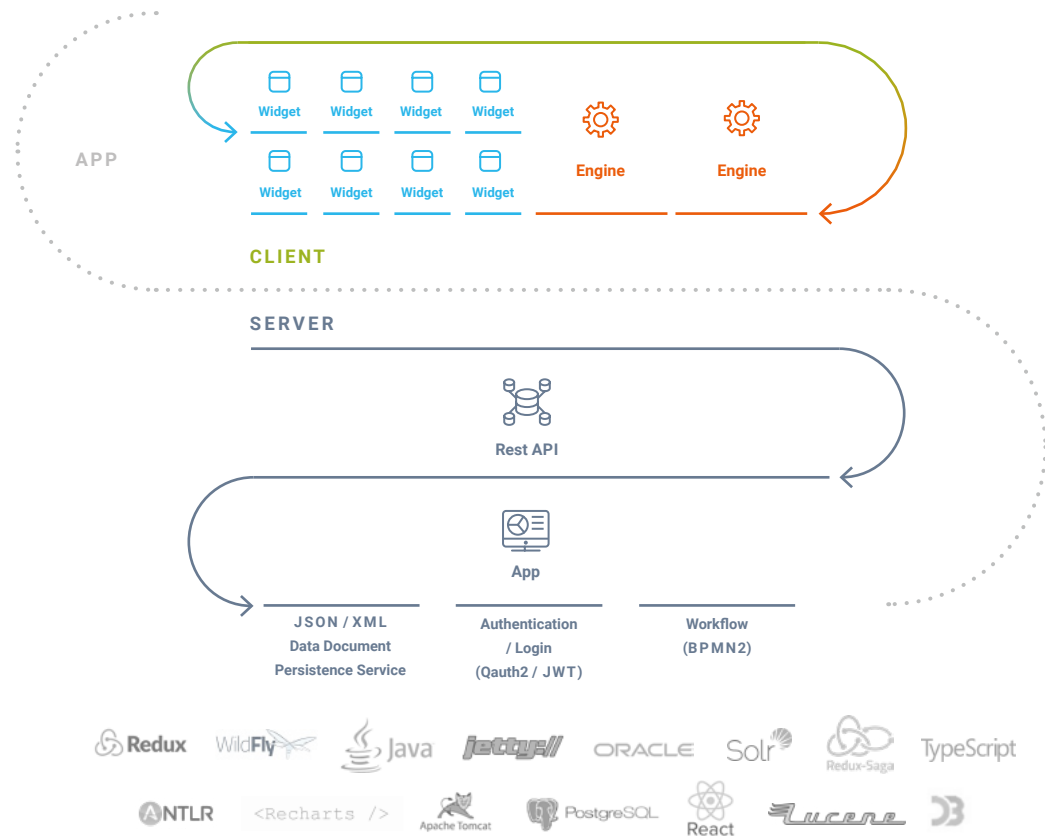
5. Runtime Platform

Architecture

The development process of business applications is continuously shaped by technological changes. A12 meets these challenges and offers a runtime platform for modern, web-based business applications. Starting from a robust core and modular solution modules, we continuously advance this platform on all levels. For this purpose, we adapt new technologies and paradigms, as long as they contribute to the goal of making the development of high-quality business applications easier, more efficient and more sustainable.

We benefit from an important capability of the low-code approach: many of the most complex and important aspects of the application are modeled in A12 and can thus be expressed in a largely technology-neutral way. In fact, even complex forms solutions survive the technology shift from JSPs and XForms (2012 and earlier) to Angular (circa 2015) to React (2017 and later). The necessary foundations - the UI engines as runtime interpreters of models - change, but the models remain.

The **A12 Client Framework** addresses the complexity and challenges of modern web applications using the single-page application (SPA) approach. It is also the basis for quickly building modularized frontends (Microfrontends). It leverages the modern and proven React/Redux technology stack, integrates A12 UI components such as Engines and Widgets, and interacts with A12 backend services such as A12 Data Services and Workflows using REST APIs. Data and models are JSON data documents. Custom backends can be easily connected, just as overall most aspects of the A12 client framework can be customized or even overridden through extension points.



The server-side A12 services provide, among others, the data services for the aspects of data storage, search, and model repository, as well as workflows (Camunda/BPMN 2), authentication/login (LDAP, SAML, OpenID Connect, OAuth 2, JWT), and user/role management. The services are built on Spring Boot

and can be used out-of-the-box, but also easily extended with customer-specific code. Behind this are supporting open source products, including Postgres as database, Solr for the search index, Camunda as workflow engine (optional), Keycloak for access management and single sign-on (optional).

5. Runtime Platform

Document-Oriented Data Access and Model Graph

The A12 architecture is based on the concept of hierarchical collections of field values in JSON documents (Documents for short). Clients can access and store these Documents. Document models (schemas) specify not only field types, but also validation/integrity rules and computations in our highly expressive kernel DSL (Domain-Specific Language). These rules are automatically evaluated by the Form Engine during form processing, for example. Search results are provided by the search service using Solr search indexes.

⊕ **Relationships** between Documents are fully supported; Documents can be linked and relationship properties and constraints can be modeled and are enforced by A12 Data Services. Furthermore, there is an inheritance concept (Subtyping) for Document models. This allows more complex domains to be expressed as a graph of Document models; we call this the Model Graph. Our tree engine uses the model graph to represent linked documents in a tree view, for example.

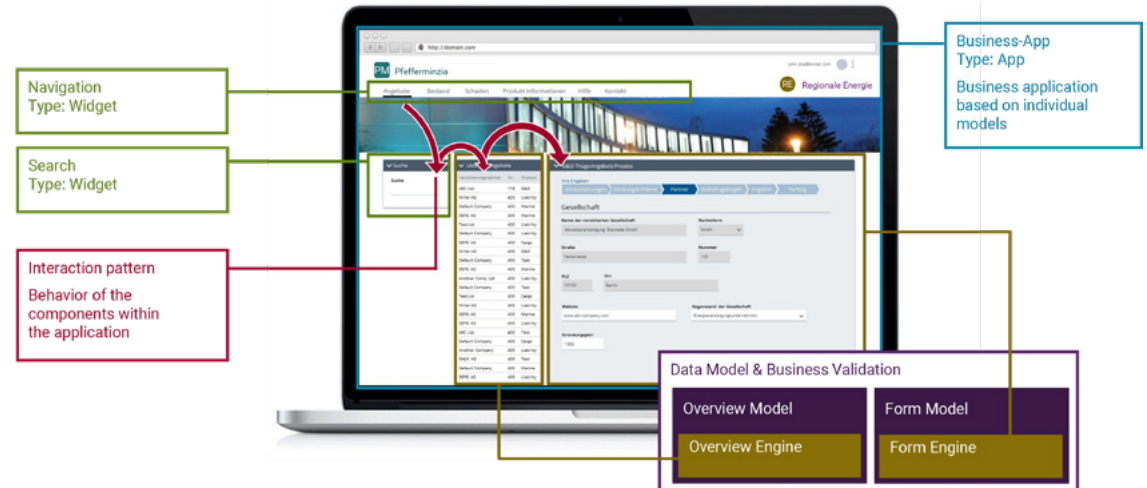
⊕ Thanks to the mentioned **CDMs**, views on the model graph can be queried, analogous to GraphQL.

⊕ **Batches**: The A12 Data Services API provides a Batch REST endpoint for transactional bundling of multiple document operations, such as creating a new document with simultaneous linking to another document. There is also an operation to partially modify documents to reduce network traffic.

A12 Frontends

The A12 architecture places a strong emphasis on simplifying client-side application development. It provides a field-proven application framework provided by the A12 Client Framework, Engines for working with models, and Widgets for reusable UI components.

The application framework uses an Application Model to control the interaction of the Engines, such as in a Master/Detail context. Written in TypeScript, the A12 client framework is based on React and uses Redux for state management and caching.



The framework offers a variety of **integrations**: a data access abstraction “Data Provider” with built-in support for A12 Data Services, the connection of process engines with built-in support for Camunda/A12 workflows (such as task lists), an A12 Data Distribution Client (data sync, offline capability), and notifications via the Notification Center.

In addition, the A12 Client Framework offers many useful and powerful features such as asynchronous flow control using Redux Saga, dirty handling and undo

mechanisms, URL routing, a layout provider abstraction with responsive defaults for desktop and mobile devices, and localization.

An A12 Frontend Client can be modularized according to the Microfrontend pattern. For this purpose, we technically use “Module Federation” from Webpack and have developed an application module registry based on it, allowing dynamic integration of these modules, for example according to user roles.



5. Runtime Platform

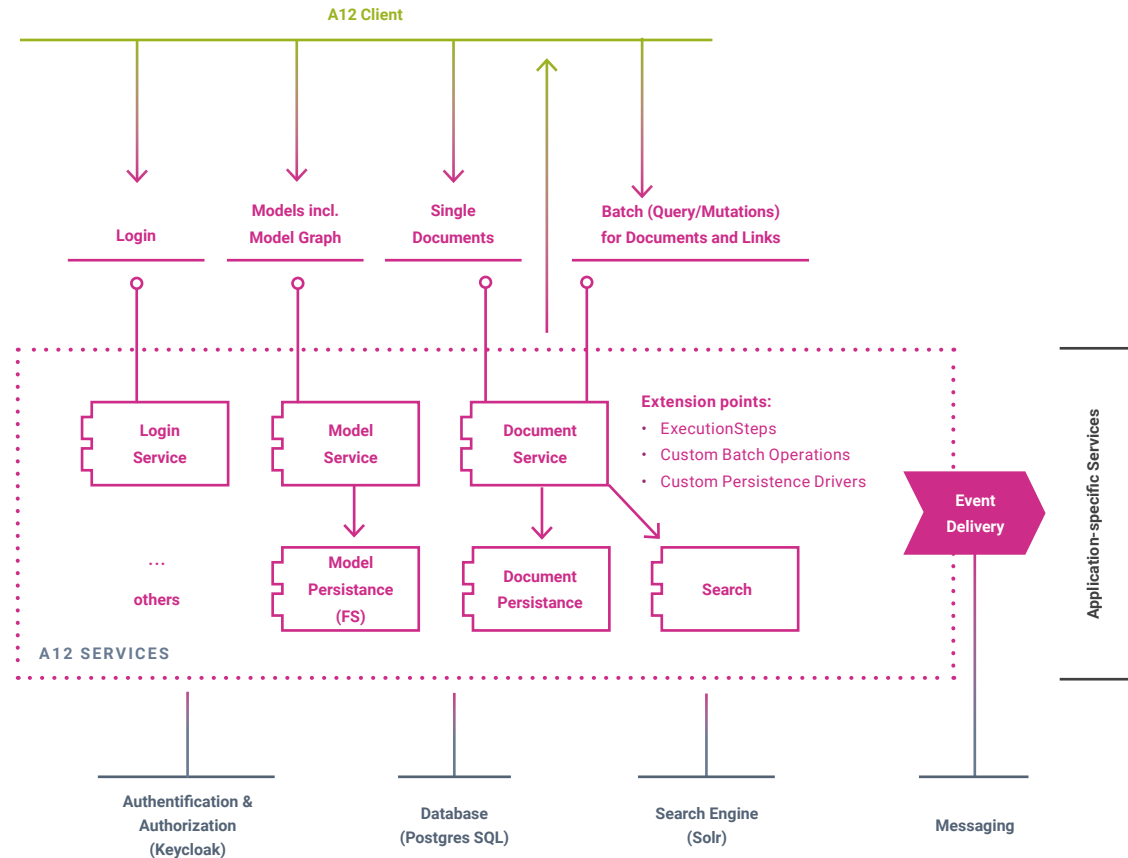
A12 Backend Services

The fundamental backend service is A12 Data Services. It provides access to models and Documents and also handles login with SSO support and optional Keycloak integration (LDAP, SAML, OpenId Connect, OAuth 2, JWT). The APIs are available as stateless REST endpoints and in Java. Persistence of Data Documents is supported by a set of reliable technologies such as Apache Solr – one of the world’s most popular search platforms.

A12 Data Services, like all other server-side A12 services, leverages the Spring Boot framework and is available in three forms: as a standalone application, as a Spring Boot project for project-specific applications with custom code, or as a library to leverage selective features in existing Spring applications. In addition, there are numerous extension points and a comprehensive event system for easy integration of custom code handling before and after operations.

For scaling, the services can be operated in a Hazelcast cluster. Such a cluster can then be dynamically adapted to the load under Kubernetes. Our A12 Project Template already offers configurations for this.

Other server-side A12 services include **A12 Workflows** (based on Camunda/BPMN 2) and the **A12 User Management Service** with IDP support (Keycloak). There is also **A12 Data Distribution**, a highly scalable data distribution and sync solution with offline client capability. The Notification Service uses A12 Data Distribution for notification delivery.



The A12 Kernel is used on the client and server side. It validates data and computes derived data based on rules and field types described in data document schemas (called Document Models). Code generation

ensures native code for both client and server. On the Frontend, the rules and calculations are executed as native JavaScript, providing immediate feedback to the user during form processing.

5. Runtime Platform

Project Scenario for the Use of A12

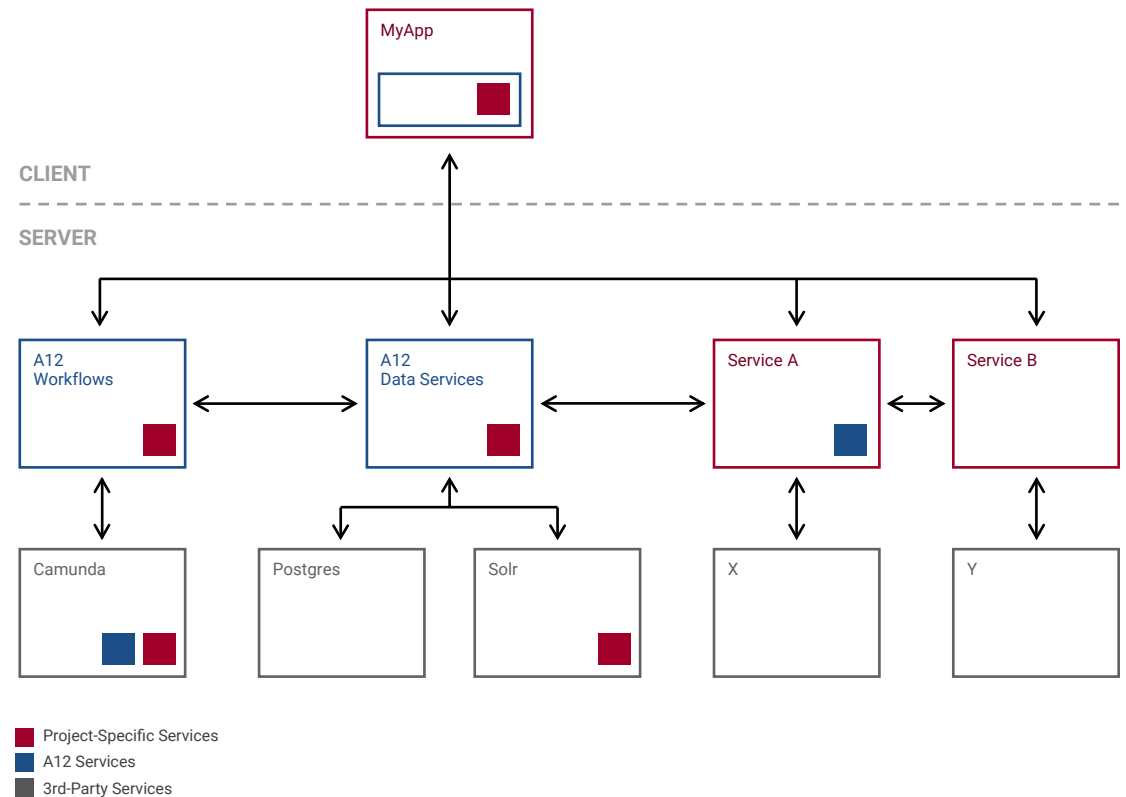
Thanks to its modular design, A12 can be used very flexibly and is also ideally suited for Microservice architectures and Microfrontends with extensive support in the framework. The following diagram demonstrates how the building blocks of A12 can interact with project-specific extensions and services as well as third-party components in a Microservice context:

About the Frontend: The resulting web application is dynamically composed of several parts and corresponding frontend projects: the application shell and two Microfrontends provided by the customer's own Microservices (A and B).

A12 components are used: the widgets and engines are customized and the A12 client framework is extended to meet the respective project requirements. For example, one can query data from the REST APIs of one's own microservices and prepare it as JSON documents via data provider abstraction, making it accessible to the engines.

The **server side** consists of

- A12 services with optional project-specific customizations and
- any project-specific services (e.g. as Microservice) with or without A12-specific extensions (e.g. the A12 Kernel as library or A12 Data Services as dependency).



5. Runtime Platform

Components

A12's runtime platform is modular and consists of a series of loosely interconnected components. Depending on the situation, they can be used flexibly in the project, even individually.

Most projects use the Client-Engine-Widget trio. Some projects use the back-end and server services provided by the Data Services module. Others write their own server depending on their requirements.



5. Runtime Platform

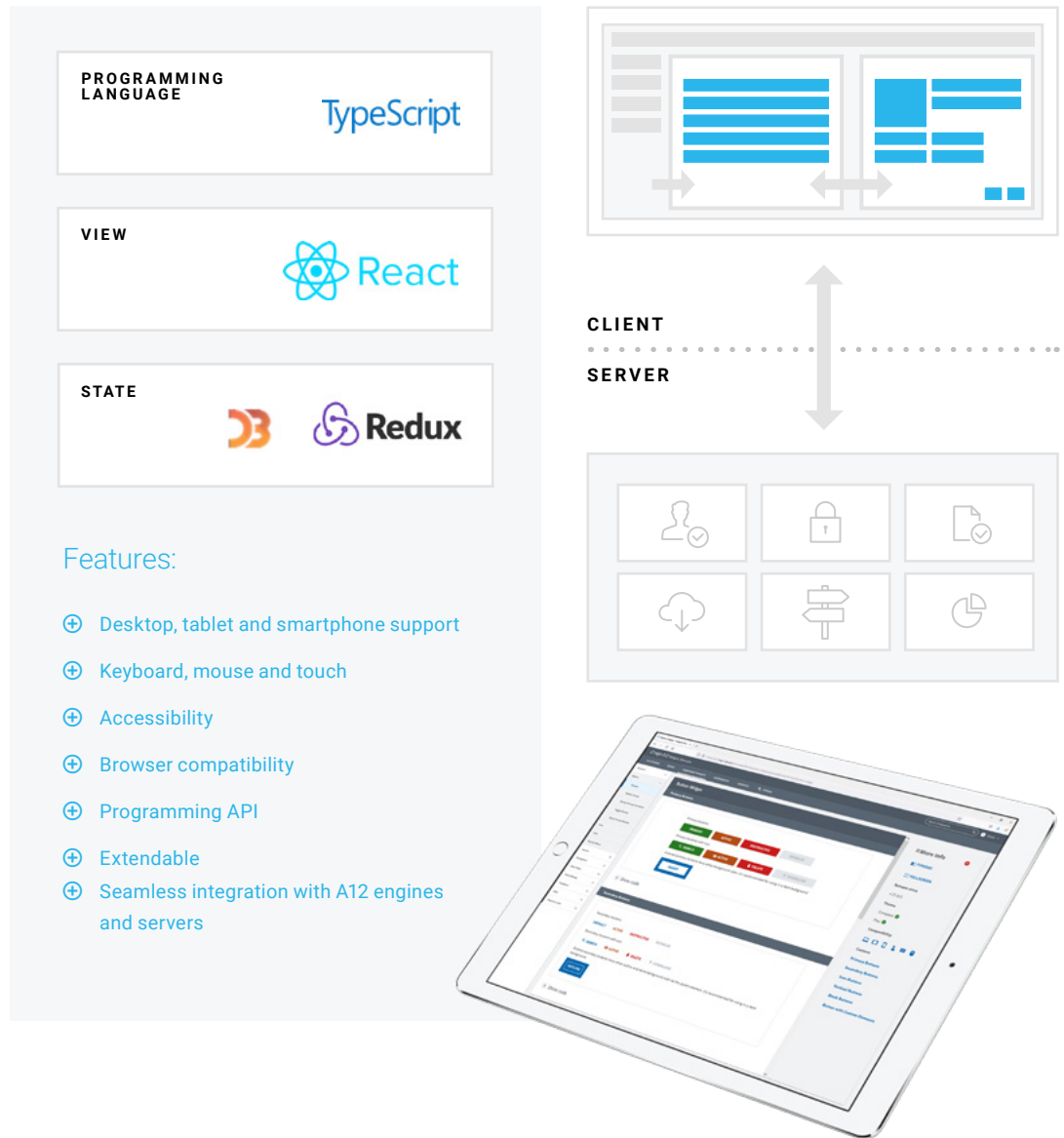
PRODUCT NAME	ABBREVIATION	DESCRIPTION
Client	C	Model-driven, client-side runtime component. Implements the UI/UX concept of the Plasma Design System and supports desktop, tablet and smartphone. Main tasks are the orchestration of other UI components, especially the A12 engines, data retrieval and state management.
Engines	E	Model-driven UI components. Engines interpret data and UI models. They are based on the Plasma UI/UX concepts and use the widgets for rendering.
Widgets	W	Widget Library, based on Plasma UI/UX concepts. See also → A12 Widget Showcase .
Kernel	K	Bundles everything for the creation and processing of document models: modeling tools, language for validations and calculations, client- and server-side runtime components, Java and Typescript API.
Data Services	DS	API for managing models and data. It also contains routines for client/server communication, validation, persistence and indexing.
User Management, Authentication and Authorization	UAA	Bundles solutions around authentication (Keycloak, OAuth 2.0, SAML, LDAP), authorization (Spring Security, RBAC, ABAC, custom logic) and user management
Workflows	WF	Integration of Business Process Model and Notation (BPMN) in A12; enables graphical modeling of server-side workflows and their execution
Data Distribution	DD	Transport layer for synchronization of data
Notification Center	NC	Communication center for notifications such as tasks, appointments and reminders



5. Runtime Platform

W Widgets

Widgets are reusable UI components that follow Plasma design conventions and UX concepts. They support enterprise applications that run on desktops, tablets and smartphones with keyboard, mouse and touch input. The components provide an easy-to-use, well documented, strongly typed API and are extensible and customisable.



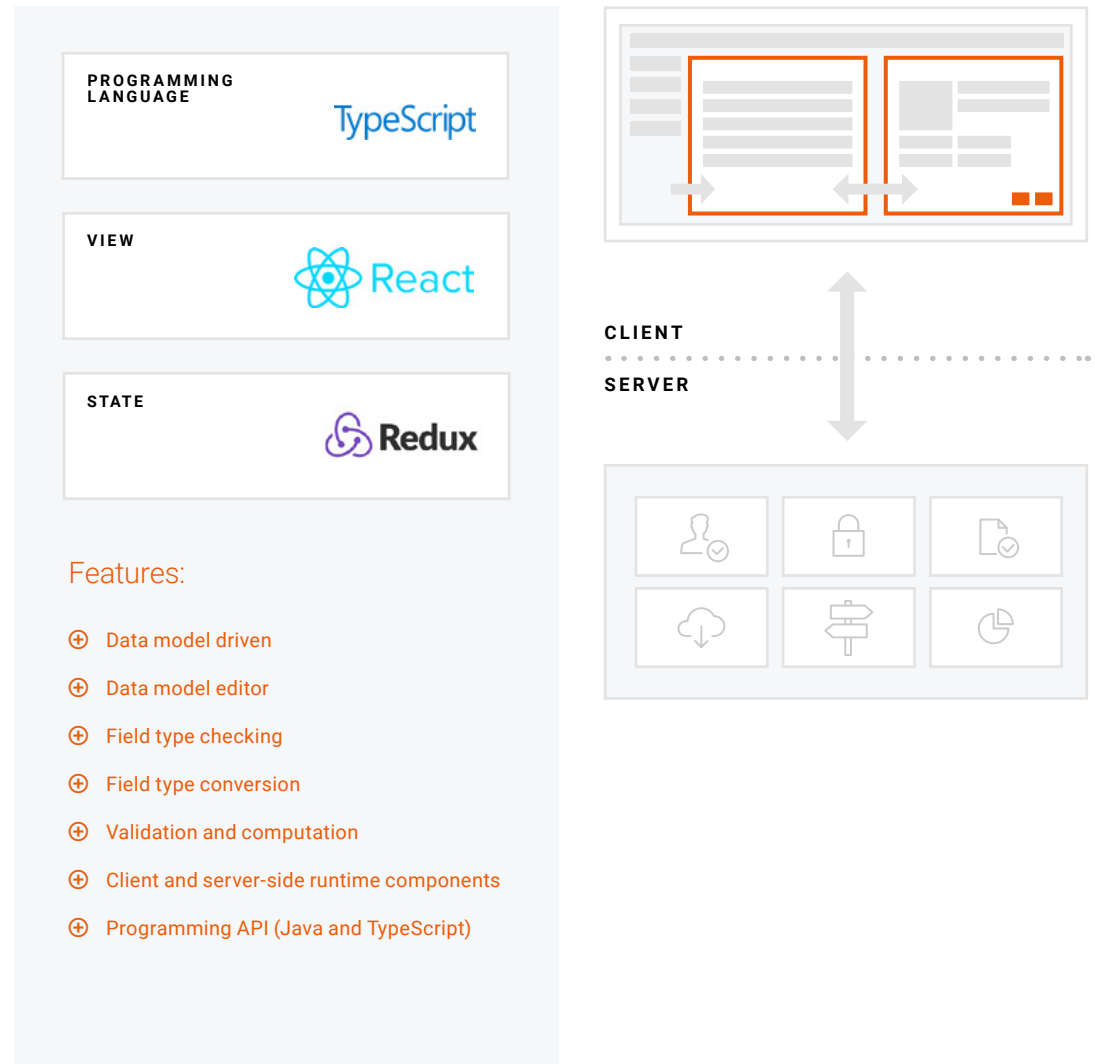
Features:

- ⊕ Desktop, tablet and smartphone support
- ⊕ Keyboard, mouse and touch
- ⊕ Accessibility
- ⊕ Browser compatibility
- ⊕ Programming API
- ⊕ Extendable
- ⊕ Seamless integration with A12 engines and servers

5. Runtime Platform

E Engines

A12 engines are implemented in TypeScript. They are self-contained runtime components that interpret data and UI models. They are based on Plasma UI/UX concepts and use widgets for rendering.

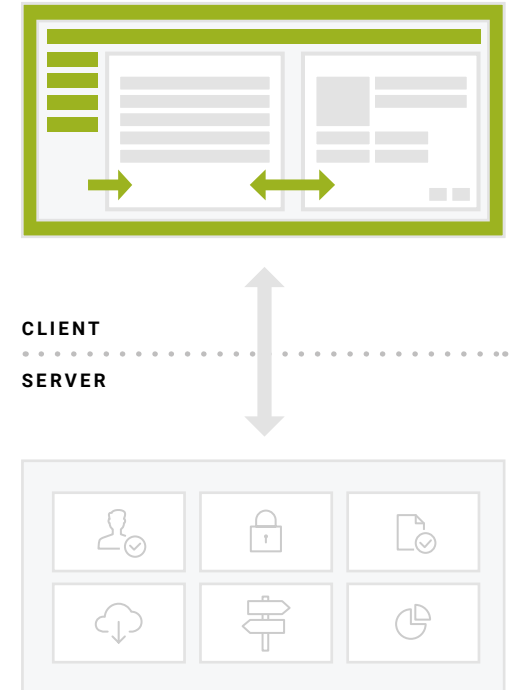
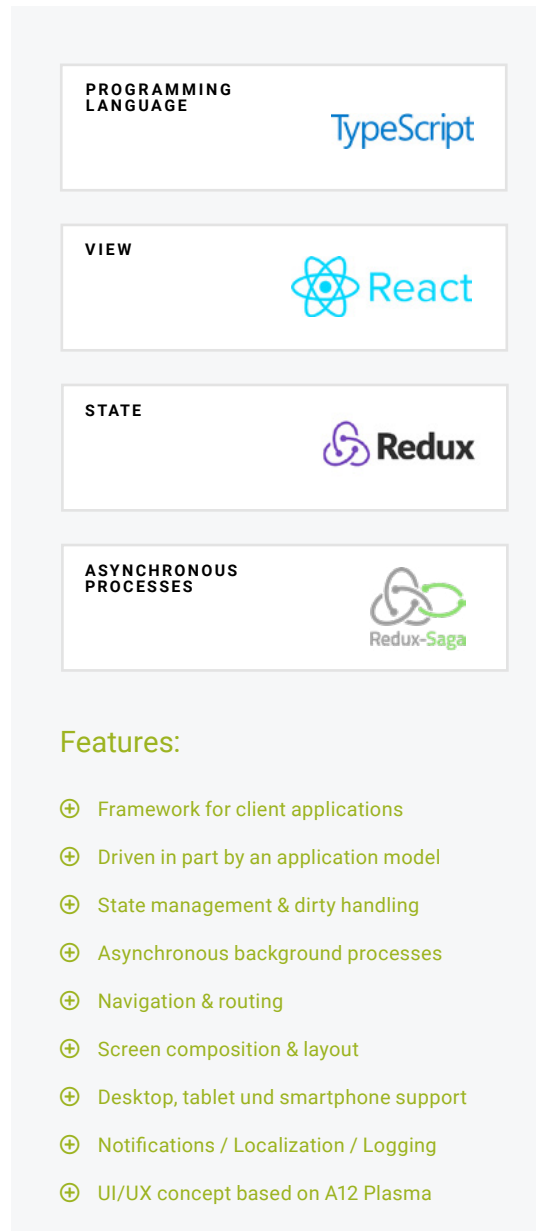


5. Runtime Platform

C Client

The model-driven, client-side runtime component makes it possible to declare the core aspects of the application, the modules, the navigation, the screens and the most important interaction patterns. Its main task is orchestrating other UI components, especially the A12 engines.

It also organises handling requests, data retrieval and processing, and status management. The client component implements the Plasma design system UI/UX concept and supports desktops, tablets and smartphones.

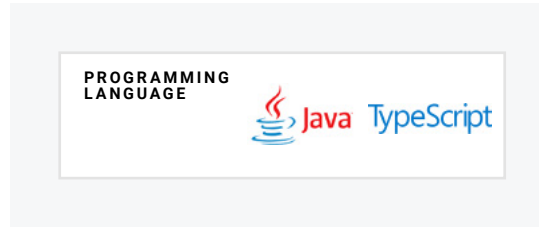


5. Runtime Platform

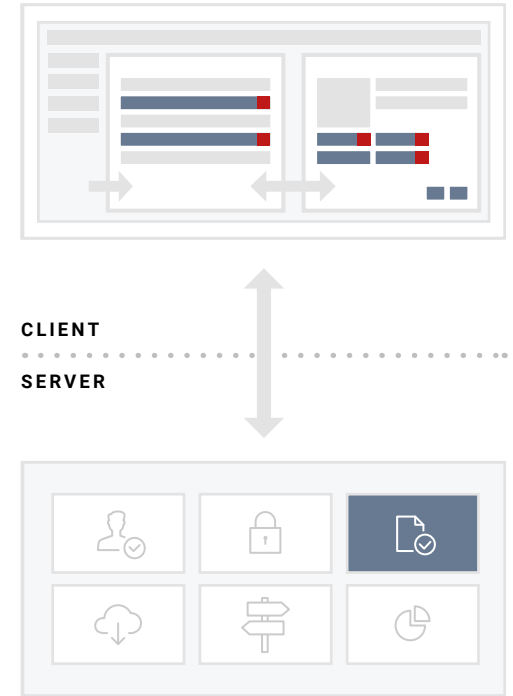
K Kernel

The kernel component bundles basic functions for creating and processing data models. Above all, it defines A12's domain-specific languages (DSL).

This includes all bases for validations and computations that are part of business modeling. The component includes client and server-side runtime components and a Java and TypeScript API.



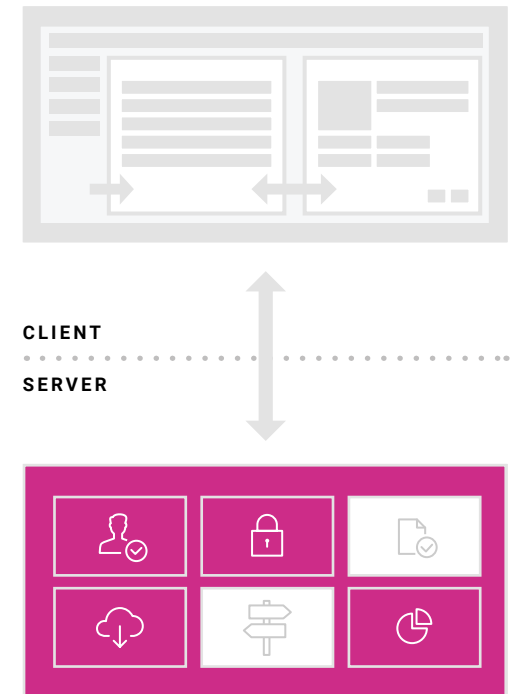
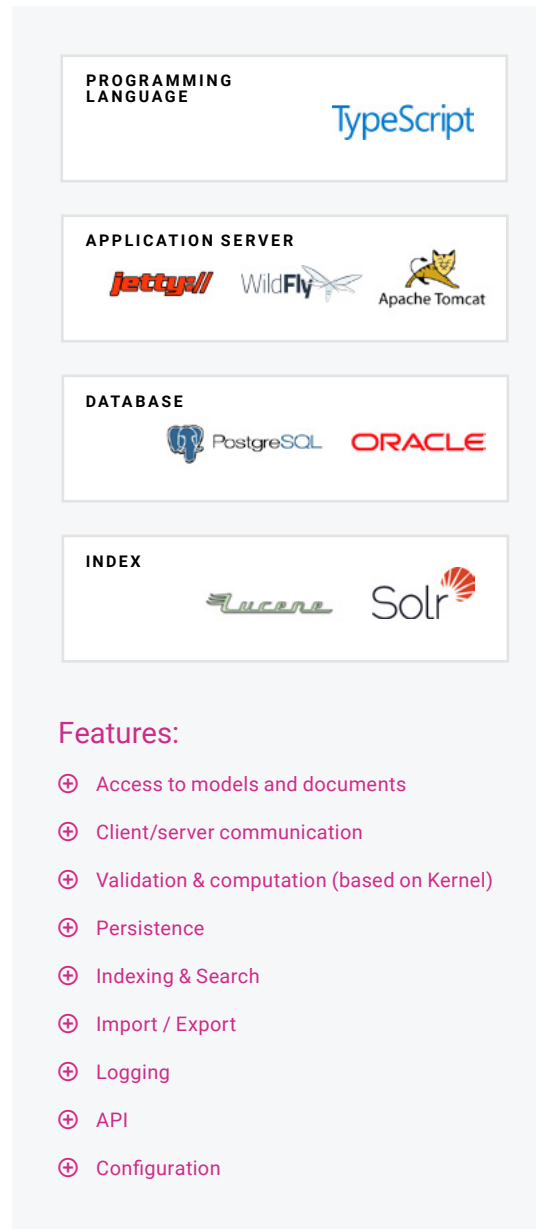
The kernel component includes the A12 DSLs, among other things



5. Runtime Platform

D Data Services

The Data Services component provides an API for managing models. It also includes routines for client/server communication, authentication, authorisation, validation, persistence and indexing. It is programmed in TypeScript for the client side and in Java for the client and server side.



5. Runtime Platform

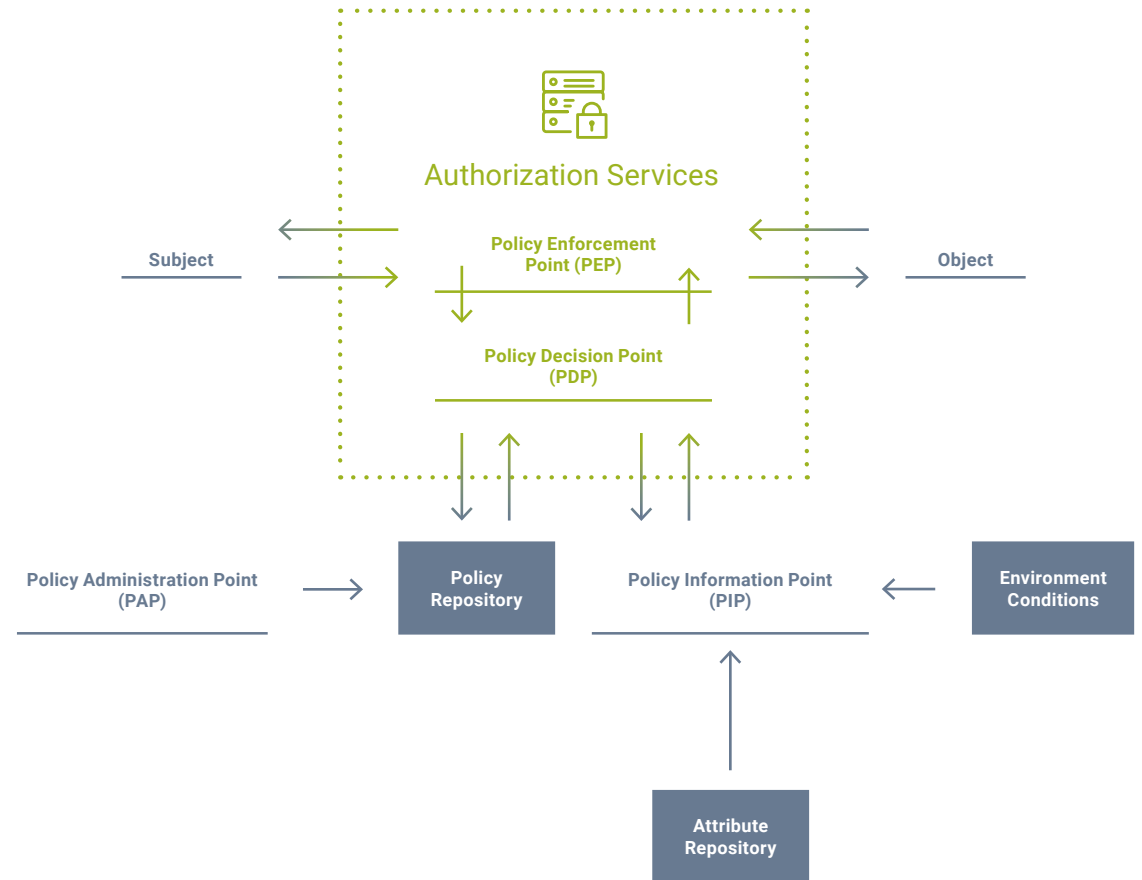
UAA User Management, Authentication & Authorization (UAA)

A12 uses Keycloak, a tried-and-tested open-source solution, for authentication. It also supports both OAuth 2.0 with OpenID and SAML token-based SSO authentication and connection to LDAP.

A12's UAA components also provide a highly flexible and powerful authorisation solution, which can provide access rights in different levels of granularity. Both role-based and more complex, attribute-based rules can be specified, thus protecting access down to the field level of data documents.

The UAA component is supplied as a library. It can therefore be integrated both in the A12 server and in the application's standalone services. The access rules and other authorisation configurations are sourced from a policy repository.

The UAA solution is based on the well-known NIST ABAC reference architecture.



The UAA solution is based on NIST ABAC reference architecture



5. Runtime Platform

WF Workflows

A12 Workflows provide a lightweight service that integrates business process model and notation (BPMN) modeling functionality into A12. This makes it possible to perform graphic modeling of server-side workflows and their execution.

The A12 workflow service can be activated as an extension to other A12 products and integrates seamlessly into the A12 architecture.

In this manner, documents can be used as inputs and outputs for A12 workflows, and the user interface for user tasks can be created using the existing A12 modelling approach.

In addition to user tasks, automatically executable tasks such as service tasks or script executions can also be modeled, allowing the realisation of partially and fully automated workflows using process modules. Camunda's BPMN Workflow Engine is used as a central component of A12 workflows.

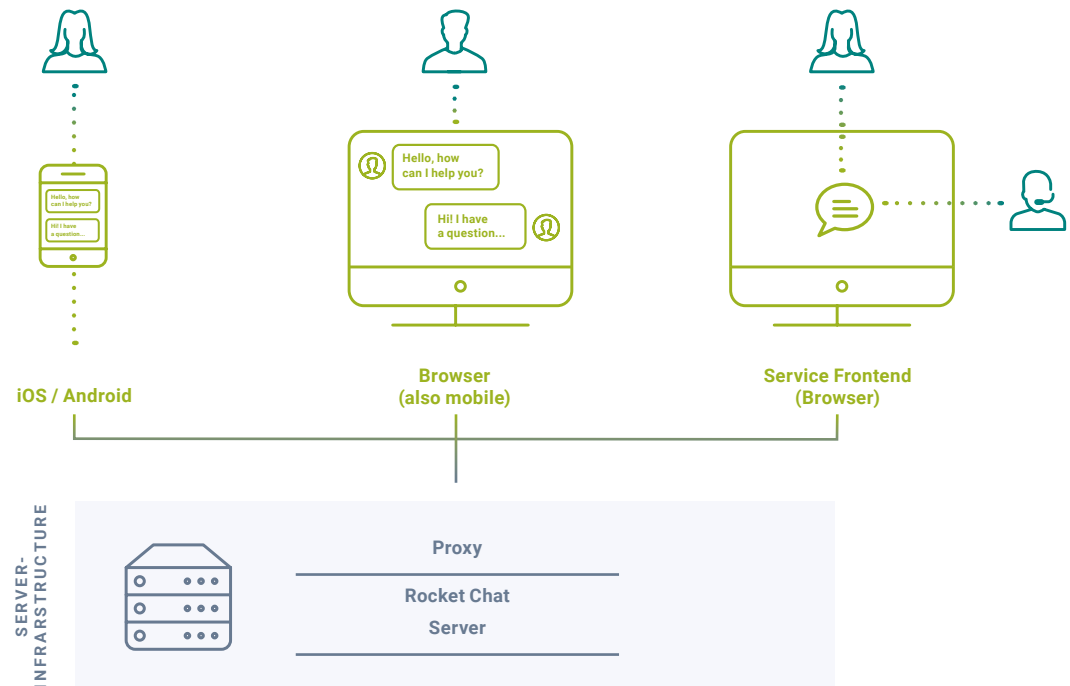
Features:

- ⊕ Model driven business processes
- ⊕ Server side / asynchronous / semiautomated
- ⊕ BPMN2
- ⊕ Camunda process engine
- ⊕ Camunda model editor
- ⊕ Integrating with A12 modeled data

Chatbot

You can easily extend A12-based applications with a chat functionality using the A12 chatbot solution. The A12 chatbot is an extension that can be activated together with other A12 products. It includes a server and client-side component.

The chatbot service uses the open source product Rocket Chat on the server. It interacts with the frontend component for fully automated chatting as well as forwarding to an employee. The chat frontend is also optimised for use on both desktop PCs and mobile devices.



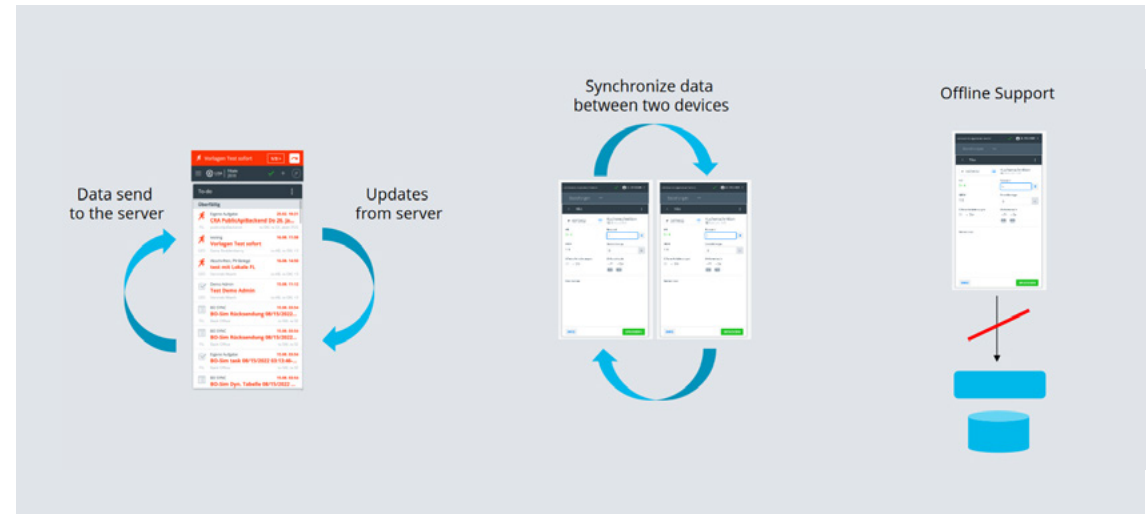
Chat add-on based on Rocket Chat

5. Runtime Platform

DD

Data Distribution

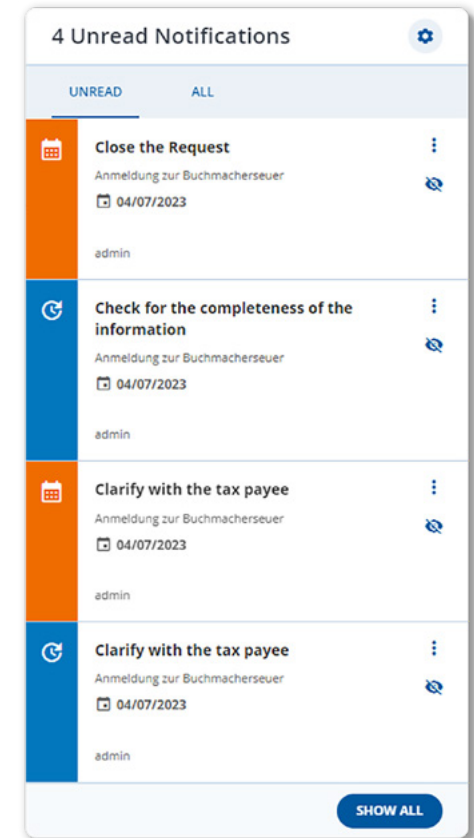
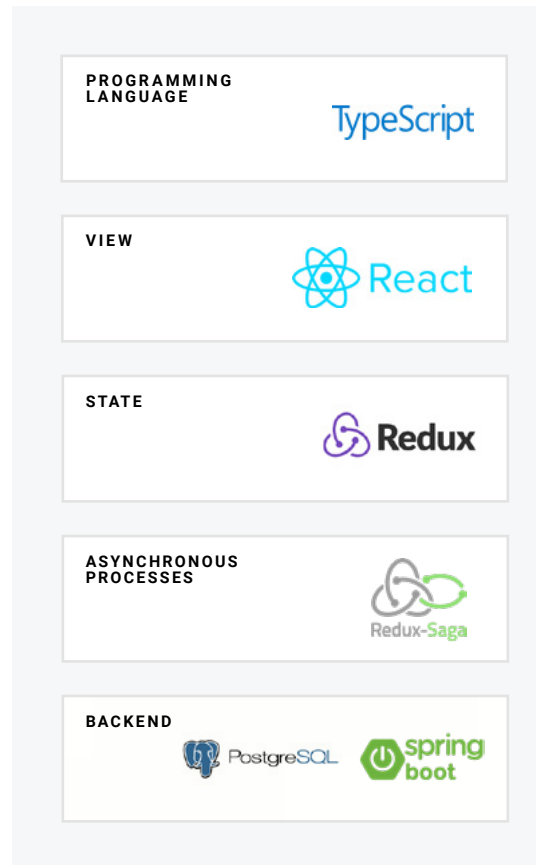
Fast and secure synchronization of data is one of the most demanding technical tasks in full-blown business applications - especially when not all systems involved are permanently online. The Data Distribution component of A12 is a transport layer that specializes in exactly this. The technical service is designed to distribute data between servers and clients and to propagate changes - especially in scenarios where clients are temporarily offline. The component's origins lie in an e-commerce project, in which it manages the data synchronization of a global store network.



5. Runtime Platform

NC Notification Center

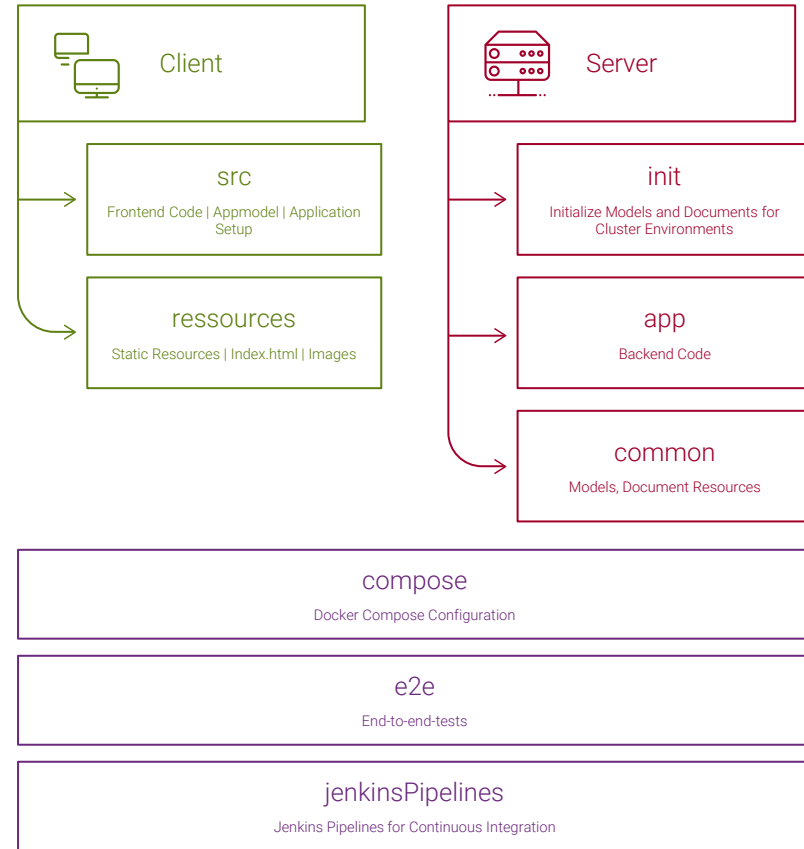
In the context of business applications, employees are typically flooded with a number of different messages. There is information about new tasks, messages from various communication channels, as well as appointments and reminders. With the Notification Center, all these messages in business applications can be bundled in one central location. It serves as **a collection point for different types of notifications** based on different business use cases, structured views, different filters and user preferences. The Notification Center integrates seamlessly with A12-based applications. It provides several predefined notification types. Using the Notification Center's API, the development team can also create their own custom notification types quickly and conveniently.



5. Runtime Platform

Project Template

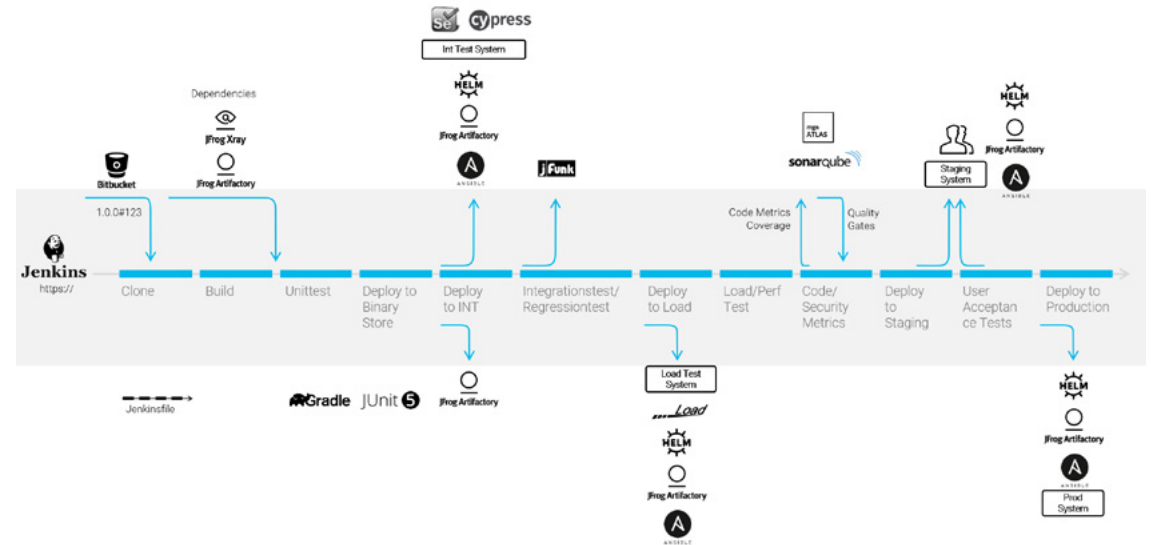
The A12 Project Template provides a starting point for development teams to conveniently set up A12 projects and quickly bring A12 applications into production. Among other things, it contains standardized build pipelines as well as development and test environments and covers basic security requirements. At its core, the template includes the A12 components Data Services, Client and UAA. Keycloak is set as the identity provider, and the authentication type is OpenIDConnect/Oauth2 in the default case. Optional components such as workflows, the Notification Center and the Print Engine can be integrated in a standardized way if required.



5. Runtime Platform

Operations

The A12 platform can be run on-premise in the company's own or external data center. In addition, mgm offers hosting in mgm's private cloud in a data center in Germany. Another option is to run it in the cloud with any cloud provider.



Cluster capability - A12 is Kubernetes-ready

A12 applications are designed for deployment on Kubernetes clusters. Built on the A12 project template, A12 provides a standardized way to build and deploy applications to all common development and production environments (DEV, TEST, and PROD clusters). Using the following templates, the DevOps team can very quickly set up and customize the build and deployment processes for A12 applications in a proven manner:

- **Helm A12 Stack**

A collection of charts for Helm - the popular Kubernetes package manager - enables Kubernetes deployment out-of-the-box.

- **Logging & Monitoring**

If the particular operating environment does not specify specific logging and monitoring solutions, A12's standardized logging and monitoring setup (based on Loki and Prometheus) can be used. The state of the overall system can be checked at any time via Grafana dashboards.

- **A12 Build and Deployment Pipelines**

Pre-built Jenkins pipelines automate the build and deployment processes of A12 applications. A build pipeline creates Docker images of an application and publishes them to a Docker registry. A deployment pipeline provisions an environment on a cluster.

5. Runtime Platform

Separate Git repository for deployment configurations

In addition to a repository for the program code, every A12 project inherently contains a repository for the configuration of the environments to which the software is deployed. Code and configuration are thus cleanly separated from each other. In addition, changes to the configuration automatically trigger certain Jenkins jobs. For example, adjusting the configuration allows a specific version to be deployed to the TEST environment. At the same time, it is always transparent who uploaded which version and when.

Hosting options for multiple A12 applications

There are a number of options for hosting multiple A12-based applications:

- ⊕ **Isolation via user rights and otherwise "mixed operation".**
It is possible to run a central A12 platform running multiple separate A12 applications. If, for example, users have access to several specialist applications, the data and model view could be controlled via rights. Services used across all applications can also be shared.
- ⊕ **Isolation through separate deployments**
If the A12 applications are to be run in isolation from each other, the A12-specific services (database, Solr, etc.) must be deployed separately for each separate runtime environment.

Modularization of deployed artifacts

The frontend part of an A12 application can be deployed as an NPM package. The models are deployed separately in the corresponding servers: the workflow model is installed (or updated) in Camunda and the data/form models are injected into the A12 Platform server (via the import API using REST call).

For the communication with surrounding systems several options are possible:

- ⊕ **Make data from the peripheral system available to the client as A12 Documents.**

Option 1: Peripheral system actively pushes data

The data from the peripheral system is actively made available by the surrounding system, e.g. via JMS messaging (transactionally secure) directly to the A12 server (which is extended by JMS listeners for this purpose). Or by calling the data services APIs remotely on the side of the surrounding system. For this purpose we offer a JSON-RPC API with CRUD and other operations. These operations can be sent in batch, which are then processed in a common transaction. But you can also define your own Spring MVC REST endpoint or JSON-RPC "Custom Operations" - this is successfully practiced in many projects.

Option 2: A12 Data Server calls repository on demand ("replaces database").

One can easily implement a custom Spring repository for a document type that redirects CRUD and list operations to the Umsystem. The repository would then not use JDBC, but work via messaging (JMS) or REST/SOAP. Note here that only JMS messaging runs in Java EE transactions.

- ⊕ **Offer operations of the surrounding system "directly"**
If the peripheral system is more likely to offer operations, or the data is to be seen directly by the client (i.e., not as A12-compliant documents), then one can provide a server-side service to the client that serves as a facade/adaptor between the client and the surrounding system.
As a standalone service, this service can be provided via Spring Boot or based on another framework or a non-JVM runtime. Authentication and authorization is provided via A12 UAA. The service can implement the calls internally as desired. REST or better JSON-RPC is recommended as endpoints visible to the client.
- ⊕ **Direct call of the surrounding systems from the client**
This is technically possible. However, direct access to backend systems without UAA is not recommended due to security concerns and SSO/CORS complications.



Appendix A: Technologies

The separation of business expertise and technology allows the technologies used to be exchanged as required. On the following pages you will find an overview of the current A12 technology stack.

6. Appendix A: Technologies

Technologies currently in use

A12 PRODUCT	TECHNOLOGY	DESCRIPTION
K Kernel	Java	
	Typescript	
	Groovy	
	Antlr	Parser generator
	StringTemplates	Template engine
	JAXB	Mapping Java objects to XML
	Jackson	JSON processor for Java
	W Widgets	Typescript
React		Building UIs
Styled Components		CSS styling
Recharts		Chart library
DraftJS		Rich text editor
React-Dnd		Drag and drop handling
React-virtualized		Rendering partial data into DOM
Redux		State management
UAA UAA	Typescript	
	Redux	State management
	oidc-client-js	OpenIdConnect authentication protocol
	Java	
	Spring	Application framework for the Java platform
	Spring Boot	Auto configuration for Spring application

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	Spring-security	Spring security approach for authorization (SpEL - Spring Expression)
	KeyCloak	Identity and access management
	OAuth2/OpenID	Protocol for authentication
	SAML	Protocol for authentication
	LDAP	Protocol for accessing and maintaining distributed directory information services over an IP network
DS	Data Services	Java
	Apache solr	Search index
	WildFly	Application server
	Apache Tomcat	Application server
	Eclipse Jetty	Application server
	PostgreSQL	Database
	Oracle	Database
	H2	Local In-Memory-DB
	Spring Security	Authentication, authorization
	Spring Boot	Auto configuration for Spring application
	NodeJS	Java runtime environment
	Typescript API	
WF	Workflows	Kotlin
	Spring	Application framework for the Java platform
	Spring Boot	Auto configuration for Spring application
	Camunda	Platform for BPMN workflow and DMN decision automation
	Typescript	Frontend
	React	Building UIs



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	Webpack	JavaScript module bundler
	NPM	Package manager for JavaScript
O	Overview Engine	Typescript
	React	Building UIs
	Stylus	CSS preprocessor
	Recharts	Chart library
	DraftJS	Rich text editor
	React-Dnd	Drag and drop handling
	React-virtualized	Rendering partial data into DOM
	Redux	State management
F	Form Engine	TypeScript
	JavaScript	
	TSLint	Analysing Typescript
	NodeJS	Java runtime environment
	NPM	Package manager for JavaScript
	Lerna	Managing multi-package repositories
	Webpack	JavaScript module bundler
	React	Building UIs
	Redux	State management
	Marked	Markdown in expression language
	Jison	Expression language
	moment.js	JavaScript wrapper for the date object

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T	Tree Engine	Typescript	
		React	Building UIs
		Stylus	CSS preprocessor
		Recharts	Chart library
		DraftJS	Rich text editor
		React-Dnd	Drag and drop handling
		React-virtualized	Rendering partial data into DOM
		Redux	State management
Chat Solution	A12 Client	Frontend	
	A12 Widgets	Frontend	
	Rocket.Chat	Web chat platform	
	NodeJS	Java runtime environment	
	MongoDB	Data persistence	
Chatbot	Python		
	Rasa	Chatbot development framework	
	Tensor-flow	Machine learning/differentiable programming framework	
	Scikit-learn	Machine learning library	
	Flask	Web framework	
C	Client	Typescript	
		JavaScript	
		TSLint	Analysing Typescript
		NodeJS	Java runtime environment
		NPM	Package manager for JavaScript



6. Appendix A: Technologies

	Lerna	Managing multi-package repositories
	Webpack	JavaScript module bundler
	React	Building UIs
	Redux	State management
	Inversify	Configuration injection
SME	Simple Model Editor	
	A12	Frontend
	Typescript	
	React	Building UIs
	Redux	State management
	Redux Saga	Library used to handle side effects in Redux
	A12 Installer	
	Typescript	
	React	Building UIs
	Redux	State management
	Redux Saga	Library used to handle side effects in Redux
	Spring Boot	Auto configuration for spring application
	H2 Database	Local in-Memory-DB
	Electron	Software framework to develop desktop GUI applications using web technologies
	Plasma Design	
	Adobe Illustrator	Creating graphical user interfaces
	Adobe XD	Creating screens and lo-fi prototypes
	Azure	Creating hi-fi prototypes
	PUG	Template engine – create reusable HTML
	BEM	Creating extendable and reusable CSS
	Documentation	
	AsciiDoc	User documentation

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	Typedoc	Generating API documentation for TypeScript
	Javadoc	Generating API documentation for Java
QA, Testing & Security	Enzyme	Unit tests
	Cypress	Integration tests
	Testcontainers	Integration/system tests based on Docker containers
	JUnit 5	Testing framework for Java applications
	MockK	For Kotlin
	H2	Local in-Memory-DB
	QFS-Test-Suite	Automated surface tests
	PerfLoad	Load testing
	Selenium	Browser automation
	Mocha	Javascript test framework
	TestCafe	Automating end-to-end web testing
	Sonarqube	Continuous inspection of code quality
	OWASP Dependency Check	Scanning for vulnerabilities
	TestRail	Managing and tracking testing
	JAX-RS	Integration tests
	jMeter	Functional behavior and performance tests
	TestNG	Unit, functional, end-to-end, integration tests
	Python	Orchestrating security test suite
	Docker	Running security test suite
	Sqlite, MariaDB	Persistent Storage for licenses, credentials, configuration
	OWASP ZAP	Dynamic application security testing



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	Postman/Newman	REST client for API testing
	OWASP DefectDojo	Security reporting and monitoring
	Xanitizer	Static application security testing
	Chai	Assertion library for Node
	NYC	Test coverage reporting
	NPM audit	Security review of project's dependency tree
	Hamcrest	Creating customized assertion matchers
Runtime	Docker / Docker-compose	Defining and running multi-container Docker applications
	Kubernetes	Managing containerized workloads and services
	Prometheus	Systems monitoring and alerting toolkit
	Grafana	Analytics & monitoring
	ELK (Elastic, Logstash, Kibana)	Log management
	Ansible	Automating configuration management & application deployment
Development-Infrastructure	Jenkins	Automation of builds and deployment
	Artifactory	Managing code repositories
	GIT	Version control
	Bitbucket	Code collaboration & version control
	Gradle	Build automation
	Maven	Build automation
	Webpack	JavaScript module bundler
	NPM	Package manager for JavaScript

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