

**VALENTYNA YUSKOVYCH-ZHUKOVSKA**

Dean of the cybernetics faculty, Academician Stepan Demianchuk International University of Economics and Humanities, Ph. D. of technical science, docent;  
*e-mail: valivanivna1@gmail.com, valivanivna@i.ua*

**OLEG BOGUT**

senior lecturer, Academician Stepan Demianchuk International University of Economics and Humanities; *e-mail: oleg.bogut@gmail.com*

## **PERSPECTIVE TECHNOLOGIES OF THE CMF DRUPAL FOR DESIGN AND DEVELOPMENT OF THE WEBSITES AND WEB APPLICATIONS**

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### **ABSTRACT**

This research examines the features of using coupled, decoupled, and micro-service architecture applying for the design of sites and web applications. Currently, gadget customers require not only static or dynamic websites but fully operational web applications that can work successfully on different devices and systems using modern information technologies.

Modern customers have a lot of requirements for web applications - they should be available on different devices at the same time: on laptops, smartphones, desktops, smartwatches, IoT, etc that could work at the same time on different devices with keeping informational context during the switching from one device to another, supporting modern data exchange formats and protocols for the possibility of deep system integration. Modern versions of CMF Drupal became to use the new architecture solutions, oriented on the API-first principle and combined with data exchange technologies: REST, JSON: API, GraphQL.

The problem of reliable and safe management of huge data structures with possibilities of the information exchange for applications built with decoupled and microservice architecture using CMF Drupal as a backend application become the main scope of current research.

### **KEYWORDS**

web applications, information technologies, CMF Drupal, user interface, decoupled development, microservice architecture, cloud technologies.

### **Introduction**

A deep understanding of the specific usage of coupled, decoupled and microservice architectures are pretty important for the successful implementation of huge and complex projects. Drupal is well known as one of the best cases for building a complex solution based on combined applications architecture.

Decoupled Drupal allows to use of system resources with pretty fine flexibility, improves the development of web applications (from a backend perspective), and provides abilities for using a wide specter of frontend solutions.

For a correct understanding, which architecture should be used during the designing of the application: coupled or decoupled - we should refer to the information model of the application. So, Dries Buytaert (founder of Drupal) highlights some features:

- The correct decision for using decoupled or coupled Drupal architecture for the development of the website or application is based on functions that are expected from the website or application.
- In case of creation of the multiple web interfaces - decoupled Drupal could be used as a content repository. Concerning the specific of the website or application, the frontend application could be created using different frameworks or libraries, for example, based on Java Script.
- The fully decoupled architecture could be used as well for developing native applications, or IoT applications, for providing an ability for customers to manage the data through the API web services [1].

Famous Ukrainian scientist, academician V. Y. Bykov considers the web as network information-communication technologies (ICT) that supports electronic communications at the networks (Web 0.0), internet technologies (Web 1.0 – Web 4.0). So, in this meaning Web – it's a kind of a basis for the Internet, a system that provides access to the cross-related documents at the different devices connected to the Internet [2].

The characteristics of the Web were researched by the native scientists: I.O. Zavadsky, N. M. Naumova, I.Y. Rivkin, K.A. Haidarov, and foreign scientists Tom Flerakers, Marko Barning, and others. But the question of the Web evolution is still actual because new possibilities of the Web appear to the market.

Currently, a lot of different solutions are available in the software market, but depends on the public experience and results of public awards - one of the most effective solutions is using CMF Drupal. First of all CMF Drupal has a lot of benefits:

- high functionality;
- flexibility;
- scalability;
- high performance;
- security;
- high involvement of the community.

CMF Drupal is one of the most popular solutions for building websites and mobile applications (decoupled development) [3].

According to [4] in 2022 some trends became most popular:

- progressive web applications;
- AMP (accelerated mobile pages);
- (SPA) single page applications;
- voice-controlled applications;
- using AI augment reality;
- chatbots with elements of AI;
- mobile-first development methodology;
- serverless architecture;
- seamless applications;
- cyber security (in the scope of web development).

Besides that, in the context of the active evolution of wireless technologies and implementation of high-speed mobile internet technologies, we could say that requirements for modern web applications are changing. And for a successful reaction from customers and the market at all - the application should satisfy technological trends and optimally solve all of the necessary functions. [5]

Using decoupled and microservice architecture allows to apply all the modern trends in the best way, more than that concerning evolution from traditional to service-oriented architectures - developers, software architects, and technical managers required more practical resources than ever. The decoupled architecture of the applications in combination with modern technologies provides these resources with full scope [6].

Using decoupled and microservice architecture allows to implement of all potential possibilities with using modern data access technologies especially one of the most effective solutions could be using cloud computing and virtualization. [7]

Using cloud computing technologies together with containerization and virtualization technologies allows providing a pretty high level of flexibility and scalability that could not be implemented using traditional hosting technologies.

It's right to say that the modern process of web development is pretty closely related to using agile methodologies of development [8]. Agile development allows managing the development process properly and with the most effective management at any stage of the project life cycle.

**An object of research:** characteristics of the CMF Drupal applying to the designing of the websites and applications, most important concepts at decoupled CMFs, researching decoupled Drupal.

**Methods of the research:** analysis of modern native and foreign science sources, web sources, comparison of different CMFs and technologies applied to designing websites and applications.

**Scope of the research:** decoupled Drupal, functions of the full and partial decoupled architecture in comparison to the functions of coupled platforms.

#### **PERSPECTIVE TECHNOLOGIES OF THE CMF DRUPAL FOR DESIGN AND DEVELOPMENT OF THE WEBSITES AND WEB APPLICATIONS**

In the field of information technologies, web development is aimed at creation of the websites and web applications. A typical process of web development consists of the next several steps:

- analysis, decomposition, and slicing of the data model and data relations;
- designing the architecture of the application, doing decisions for technologies of implementation;
- implementation of the backend (including data exchange interface);
- implementation of the frontend (including data exchange interface, templating, and data output system);
- code quality;
- launching project using DevOps technologies.

Modern trends of web development depend on the wishes and requirements of customers. Developers of web applications from their side are trying to create applications most useful and functional.

For example, chatbots are already allowing to answer the typical questions from users and help with navigation across the website or applications. AI-based on neural networks and machine learning are already helping to implement marketing targets like a targeted advertisement, contextual search, etc.

These technologies are highly demanded in the bank and economical area, medical area, e-commerce, government: all the areas where requirements on the client orientation are very high.

In comparison to the human operator - the chatbot can work without rest, whole day and can operate data with pretty high performance. Effectivity of the chatbots is very high for the typical cases. But for non-typical cases and scenarios at the current moment, the human operators are preferable as they could be more sensitive to the right decisions. This problem has a straight perspective for replacing with AI in the future because AI and machine learning technologies are improving pretty quickly.

Another case of the web development trends could be using progressive web applications. PWA is a technology that allows doing a visual and functional transformation of the website into a mobile browser application. This approach allows to make service in general and especially UI more usable and suitable for customers. At the same time, this feature allows making the applications more popular for users. This methodic is actively used for Uber, Pinterest, Aviasales applications, etc. Using the PWA provides fast and usable access to the content on mobile devices - this is pretty important nowadays.

AMP technology allows managing more fast content loading. Also, this technology is pretty fine using for animation and video content, as it allows does not overload the main content.

Voice control of applications is another technology that became more and more popular especially for gadgets users. So, for searching the necessary information the voice application control using at Google search. Also, this technology is one of the bases for communication with IoT devices. Most of the modern devices are compatible with this technology, so there is a high probability that voice control will be actively used at the websites and web applications.

There are three main ways of building the Drupal application architecture. It's coupled, partially decoupled, and decoupled architecture.

Coupled Drupal is a monolithic system that provides full control for visual elements with quick access to the editing options and content management at each page. The system is monolithic in this case because backend and frontend components of the application are implemented by the CMF Drupal resources at all levels: content management, templating, and making application responses management.

Partial decoupling means that content editors could manage the content using resources of Drupal, but at the same time content is displayed to customers via the client application. In this way, CMF Drupal is a data source, but the client application makes content generation by interaction with Drupal through API.

From version 8 Drupal supports JSON: API and REST in the system core, which allows to implementation of modern solutions of the decoupling. For example, integration of Drupal with Gatsby framework allows to generate static content and place it to CDN and this solution allows to build application with pretty fast response.

The COVID-19 pandemic quarantine limitations were an additional point that increased the demand for websites, web applications and deep integrations between business and web. It's pretty visible at different areas: e-commerce, education, medicine, government, etc.

The evolution of the Web is endless process, and modern trends are producing new technologies and optimizing existing ones. So, research in the Web is still necessary, because anyone cannot provide and support growth of the modern internet technologies without understanding the entire methodology and parading of Web.

## **DISCUSSION**

Modern ways of the software development anticipate the active wide usage of the most modern technological and architectural solutions, especially ones that allows to make effective scalability due to the increasing of the system loading. Also another keypoint is effective integration of the software with external applications and systems.

Traditional way of web development used monolithic architecture in the beginning. So, first websites used static content (at the initial stage of the wide world web growth), where the content was generated by the web master (it's specific for WEB 1.0). Later the paradigm of the content creation was improved, and system customers became to be main content generators (this paradigm also known as WEB 2.0).

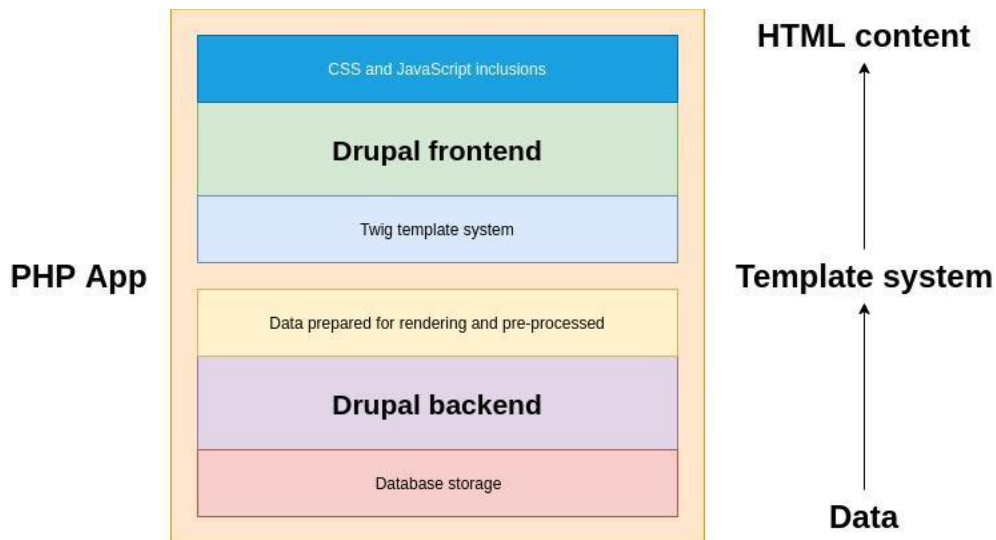
Further growth of the website content management process became implementing and wide usage of the content management systems (CMS) and content management frameworks (CMF). Currently this solutions are most widely used instruments for building of the websites and web applications.

Modern ways of building web sites and web applicationd are based on the one of the basic architectures:

- coupled (monolithic);
- fully decoupled;
- pseudo decoupled;
- progressively decoupled.

Let's provide characteristics for the mentioned architectures using CMF Drupal.

Coupled (monolithic) architecture means that data operations and generation of the content producing in scope of one monolithic (by structure) application. The architecture of application provide whole cycle of the content operations: editing, saving to database, operation using specific business logic, preparing the output using templating, and output of the content to the client terminal (it's a client browser as usual). Important thing that coupled architecture keeps vertical structure of the application (see pic. 1)



Pic. 1. The structure of the monolithic web application.

The main benefit of the monolithic architecture is a simplified development, high speed of the development and cheaper price of the project depends on that. Web applications created using monolithic architecture requires relatively simple support, so costs of technical support also looks cheaper during all the life cycle of application.

Drupal 9 provides monolithic architecture by default “out of the box”: content management, templating, building the output - all this operations are covered by coupled architecture. This solution is suitable for most part of small and middle (by difficulty and complexity) projects.

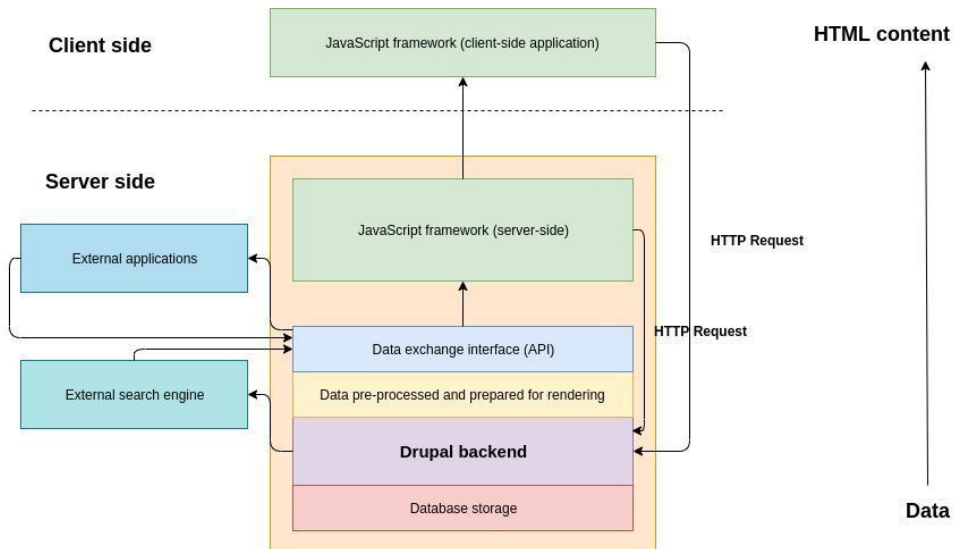
The most imperfection of the monolithic architecture is a relative difficulty of integration with 3rd party services, because this possibility is not designed as part of the basic application architecture, and requires additional development.

Changing the application’s architecture is a difficult project, and sometimes it could be not possible. But in case of Drupal the architecture of application could be improved, even when original application as designed with coupled architecture. It’s possible due to the specific of the Drupal CMF: it’s supporting REST and JSON:API as part of system core. So, application architecture could be changed from coupled to partially or fully decoupled during the application lifetime. This kind of changes requires some additional efforts, but this feature is possible and could be implemented without of the full re-design of the application.

Also, decoupling could be used only as part of integration with external application or services, but main application at the same time could continue to use coupled approach. Decoupled architecture is a more effective solution for web applications that designing for wide integration with 3rd party services, provided APIs, sharing data, etc/

Decoupled development requires dividing the functionality of the content generation between server side application and client side application. Using the decoupled concept we could highlight backend and frontend components as separate technological decisions that allows to make parallel development of the server side and client side application components as well.

Also, this architecture provides flexibility and modularity of the application. So, if we will take a look at the sample of the typical web application architecture based on Drupal CMF we could see that CMF in this case take a role of the content management system, data repository, and provides the API interface for data exchange as for middleware applications (for example server side JS like Node.js) for further integration with a client application that could be implemented for example using ReactJS. Also, it could be used for data exchange with external applications, for example mobile applications, etc (see pic. 2).



Pic. 2. General structure of decoupled application

Additional benefit of decoupled architecture - it's ability to build application with multiple technologies, so with this approach we potentially could use the best points from each technology and combine them together in conclusion. So, for example by this way we could combine Drupal in backend as data source and content management system, ReactJS application for frontend application, Elasticsearch as search engine and fast data storage and NodeJS as middleware. In this example each technology has it's own strong and weak points, but together they could be used for building successful application.

So, by this way we could see that decoupled architecture provides the abilities for the application became not only just traditional application (website, webportal, etc) but also as SaAS (Software as Service) provider. By this way, resources provided by the backend application could be used by multiple external applications (because current architecture has pretty fine possibilities for scalability using technologies of virtualization and containerization, for example using Docker, Kubernetes and cloud solutions).

The modular approach also allows to select separate components of the application in a scope of autonomic components that could be isolated at the infrastructural level as separate Kubernetes pods that increases the system stability in general. At the pic. 2 we could see search engine component that selected and isolated by this way (ApacheSOLR or Elasticsearch could be used as search engine in this case).

Also, due to the SaAS usage it became possible to use microservice architecture as component of the main architecture of application. Using microservices allows to divide the system loading in context of different business processes (separate microservice could deal with a separately selected scope of operations). Also, separate microservice could be easily scaled up using Docker and Kubernetes.

Let's review briefly, how the usage of containerization and virtualization together with cloud technologies allows to organize optimal usage of web application and allows to provide possibilities of horizontal and vertical scalability.

Usage of the typical solutions (VPS, VDS, Dedicated servers and clusterization based on these solutions) makes some imperfections for further usage of application: in case of increasing loading or when system is going out of system resources due to the huge amount of users or other kind of loading - in this case system became unstable, and possible denial of service could happen. Risk of this case became high in this case.

Potentially system became sensitive for DDoS attacks, and increasing of the system resources is not solving the problem completely, and at the same time requires active efforts from the system administrator that means additional increasing the time of resolving the critical situation. Also, it's potentially could require downtime of the infrastructure for some time.

These potential issues are providing some limitation to characteristics of application and in some cases are making the benefits of decoupled architecture bit worst: decoupled architecture has high potential stability for impacts, but unstable infrastructure could be a problem that does not solving by this features.

As alternative to the traditional way we could highlight technologies of containerization and virtualization together with cloud technologies.

Technologies of containerization allows to organize components of the application architecture as isolated elements (containers). Currently, the most used system for containerization is Docker, that provides high level of flexibility with container management.

So, separate components of the application could be placed to the separate containers and when loading is increasing - container management system going to do the horizontal scalability by creation "clones" of the necessary container. It could be implemented by the proper setup of load balance. One of the most used container management system is Kubernetes.

Also, using of containers is pretty suitable for microservice approach. In this case each service could be isolated to the separate container, and could have it's own rules of scalability, usage of resources, and usage limits. So, even if one separate service will take a limit and will have a case with deny of service - it will be not so critical for the entire infrastructure, because all other containers will be working properly, and by this way the system will be in stable state in general.

The proper container management could be a basis for flexible horizontal scalability, because it could be limited only by the resources of the environment.



Just let's say that containerization system could be implemented at the environment based on the typical hosting solutions, but this infrastructure will be not stable in some cases, because horizontal scalability could be limited by the environment resources of those specific server or virtual server.

As alternative that allows to omit this limitation - the cloud system could be used: Amazon AWS, Google Cloud, Microsoft Azure, etc. Cloud technologies are not have direct limitation for the usage of the resources (because necessary resources could be increased without necessity of full re-configuration of the infrastructure) - so usage of containers became more effective. Another keypoint is a fact that cloud technologies allows to bypass the limitation of the application performance for users from different locations - because the biggest cloud providers have datacenters located at the different countries or event continents, so by this way the clusters could be built with specific of the location, and this feature provides optimal level of the performance for users from different locations.

Also, applications built with decoupled architecture could show all the designed potential because infrastructure is not limiting application at all. Let's agree that cloud computing solutions are still more expensive in comparison to traditional hosting solution, but at the same time they are providing higher level of stability of application. So, in the each specific case - infrastructural decisions needs to be decided with deep understanding of potential loading level and necessary system resources.

Let's conclude some keypoints about the decoupled approach of the development, and let's highlight most benefits of this approach:

- modularity due to the decoupled architecture;
- higher stability due to the isolation of system components;
- higher flexibility for horizontal scalability;
- open data exchange interface the increase the ability of application integration;
- possibility to use SaaS architecture for building complex services;
- possibility of scalability;
- possibility of parallel development, that not affecting the system in general.

Besides that, current approach has a weak points:

- design phase requires more attention to details and relations between components in comparison to coupled approach;
- development of the separate components takes more time and resources in comparison to monolithic approach;
- difficult architecture requires more qualified and skilled developers at all of the development stages;
- difficult infrastructure requires usage of modern hosting technologies, for example cloud hosting with containerization and virtualization;
- support of decoupled project requires more time and efforts, because more components and technologies are involved for building application.

So, by this way after comparison of benefits and weak points of the decoupled architecture we could conclude that current approach has high effectivity for building huge projects, for example government services, commercial solutions for enterprise level, because development using this approach requires a lot of resources and could be a good decision when applications should provide a lot of different functionality.

For small project and applications with limited functionality more reasonable to use default way: using coupled architecture.

Both architectural approaches are usable and could be used for building successful applications, but selection of the architecture and technologies should be depended on the deep analysis of the business model and data structure for making right decision.

## CONCLUSION

After deep analysis of the technologies for designing and development of websites and web applications we highlighted that combining of coupled, partially decoupled and fully decoupled approach makes Drupal a powerful solution for development of applications. Also, Drupal simplifies implementation of the decoupled application by the usage of REST, JSON: API, GraphQL standards.

According to comparison of coupled and decoupled architecture we could see that both approaches are effective at specific cases.

Decision for selection functionality for one specific project relies on the specific requirements and business goals that producing the prototypes of the features that should be implemented in conclusion.

Current trends of web development are oriented to minimalism and simplifying, so decoupled and microservice approach of the web development became more popular.

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## PERSPEKTYWNE TECHNOLOGIE CMF DRUPAL DO PROJEKTOWANIA I ROZWOJU STRON I APLIKACJI INTERNETOWYCH

### STRESZCZENIE

Niniejsze badanie analizuje cechy korzystania z architektury sprzężonej, decoupled i mikrosługowej stosowanej do projektowania witryn i aplikacji internetowych. Obecnie klienci gadżetów wymagają nie tylko statycznych czy dynamicznych stron internetowych, ale w pełni działających aplikacji webowych, które mogą skutecznie działać na różnych urządzeniach i systemach wykorzystujących nowoczesne technologie informatyczne.

Współcześni klienci mają wiele wymagań, dotyczących aplikacji webowych – powinny być one dostępne na różnych urządzeniach jednocześnie: na laptopach, smartfonach, komputerach stacjonarnych, smartwatchach, IoT itp., które mogłyby działać jednocześnie na różnych urządzeniach, z zachowaniem kontekstu informacyjnego podczas przełączania z jednego urządzenia na drugie, obsługujące nowoczesne formaty i protokoły wymiany danych, dla możliwości głębokiej integracji systemu. Nowoczesne wersje CMF Drupal zaczęły wykorzystywać nowe rozwiązania architektoniczne, zorientowane na zasadę API-first i połączone z technologiami wymiany danych: REST, JSON: API, GraphQL.

Głównym obszarem aktualnych badań staje się problem niezawodnego i bezpiecznego zarządzania ogromnymi strukturami danych, z możliwościami wymiany informacji dla aplikacji zbudowanych w architekturze decoupled i mikroserwisowej, z wykorzystaniem CMF Drupal, jako aplikacji backendowej.

### SŁOWA KLUCZOWE

aplikacje webowe, technologie informacyjne, CMF Drupal, interfejs użytkownika, decoupled rozwój, architektura mikroserwisowa, technologie chmurowe.



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