

# Notification System with Channel Management

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**Abstract** — Communication in organizations is a challenge, especially regarding collaboration between their members, where useful information must flow efficiently. Information and Communication Technologies (ICT) play a key role in this context by providing a wide range of communication channels. Some of these channels are accessible by any citizen who owns electronic devices, namely a mobile phone, which is the most used device in the world and a useful work tool. This device by itself allows people to access email, Short Message Service (SMS), make phone calls, etc. However, those who send or receive a message might have different preferences of communication channels. They may prioritize a communication channel or even a message topic. The existence of communication systems capable of managing these preferences and acting according to them are necessary to improve the efficiency of information transmission. This paper proposes and describes an integrated communications platform capable of receiving messages from different software applications and sending them through different communication channels to its recipients according to those preferences. Organizations might also have trouble integrating new channels into their information systems, that is why this platform provides mechanisms to ease that task. Recipients' personal contacts are hidden from the messages' senders and can be managed by them. It has been found that this platform is conceivable and it has been proved useful in the context of school organizations and the adoption of instant messaging channels is the most relevant.

**Index Terms** — messages delivery, communication efficiency, organizational communication, communication channels, integration platform

## I. INTRODUCTION

There are several communication channels such as email, phone calls or even the alarm that sounds in case of fire.

The purpose of these channels is always the same: to convey relevant messages to their recipients. However, no channel guarantees that the transmitted message is delivered and received by the recipient. There's a lack of communication efficiency, but it can be increased by transmitting the same message using several channels. This is relevant to various organizations such as schools and companies that need to inform their employees or clients as soon as possible about the latest news, emergency situations, events, recruitment processes, etc. Effective communication between employees is beneficial to a company's productivity. It helps to keep them aligned with their main goals and purposes [1].

In recent years, there has been a rapid and steady growth in the number of channels, mainly digital channels. Proof of this is the launch of WhatsApp Business in 2018, the exclusive

version of the instant messaging platform WhatsApp for businesses, or the 2 billion messages exchanged monthly between companies and their customers on Facebook Messenger, a similar platform [2]. Actually, Messenger features a Customer Chat Plugin [3] which allows integration in company websites, thus giving employees flexibility in choosing the platform through which they intend to interact with clients or their colleagues.

Human civilization is moving towards a culture of dependence on technologies [4]. Technologies such as the global computer network and mobile phone which is the most used device in the world [5] are directly linked to the phenomenon of globalization because they allow two or more people anywhere in the world to communicate at any time. This global network called the Internet has come up with countless ways of communicating.

It appears relevant a platform that speeds up the process of adopting new communication channels for organizations, since it might be a complex task, involving putting their online services down for a while, which is highly inconvenient in this type of civilization that demand highly responsive services and moves rapidly to alternatives. In this sense and in order to increase the need for communication efficiency, a Notification System, which can be easily integrated in organizations' computer systems, seems to be the right solution. Also, with new privacy regulations like Europe Union's General Data Protection Regulation (GDPR), private data like people's contacts deserve a special attention. This system can hide these contacts from message senders and allows people to manage them as they wish.

## II. RELATED WORK

An overview over communication channels, solutions and technologies is provided in this section.

### A. Communication Channels and Existing Platforms

Voice call is one of the most ingrained means of communication in modern society [6]. 66% of a company's customers tend to switch to competition in case of poor telephone service [7]. This service is provided by mobile operators.

With the globalization of enterprises, there is a need for online collaboration techniques for real-time video communication that enable live streams and online meetings between business teams across continents [8], thus avoiding long travel times and associated costs [9]. Skype for Business is one of the most widely used videoconferencing collaboration

solutions [10]. It is a service usually provided by instant messaging platforms like Facebook Messenger [11].

Short Message Service (SMS), which is provided by mobile operators, plays an important role in emergency situations. Mobile phones integrate this type of service by default. The number of messages sent per month increased from 12 million to 135 billion between 2000 and 2010 [12].

Electronic mail (also known as email) is used by almost all companies as a central communication medium [13]. By the end of 2018, the Gmail service reached 1.5 billion users [14].

The use of instant messaging services improve the perception of interactivity in the work environment, promoting the debate of ideas, emerging issues and mutual understanding among co-workers [15]. Facebook Messenger and WhatsApp are currently the main instant messaging services [16] [17].

In recent years, the discussion about the positive and negative effects of using social networks in society and organizations has been enormous (Akram, 2017). But their use keeps increasing and their impact on society is highly significant. Facebook is the most used social network in the world with 2.271 billion users in January 2019 [18].

Push notifications is a technology essentially used to send notifications via browser or mobile apps regarding alerts, updates on social networks, weather updates, etc. In marketing, the use of custom push notifications is reflected in a higher rate of campaign adherence [19].

There is also solutions integrating many of these channels at the same time like MailClark, which can be integrated into Microsoft Teams, a widely used collaboration software [20], SendPulse, a marketing platform that offers an automated way to send messages through multiple channels, and Regroup Mass Notification, which also optimizes the communication efficiency in emergency situations. These solutions are compared with the Notification System in the Validation section.

### B. Access Control and Privacy Regulations

An Access Control List (ACL) provides a mapping between entities such as a user or group and a set of permissions to access resources made available by a computer system, such as reading and modifying private data. This way, unauthorized access to this data is prevented. The use of ACL is important to prevent attacks that can cause irreversible damage to organizations' computer systems or violate privacy laws such as GDPR.

General Data Protection Regulation (GDPR) is a European law regulation on the privacy and protection of personal data applicable to all individuals in the European Union and the European Economic Area. Organizations subject to this regulation should adopt privacy policies in order to respect it, otherwise incurring fines or sanctions [21]. This regulation imposes the implementation of an opt-in policy, a process in which a person must insert their personal contacts, such as an email address, on a form provided by an organization that, upon submission, gives the organization the right to contact them through these contacts. A communications platform such as the Notification System makes use of personal contacts to deliver messages across different channels. It must therefore respect existing policies.

### C. Technologies

The following technologies may be required in this system:

#### 1) Communication Protocols

Hypertext Transfer Protocol (HTTP) is a "client-server" stateless protocol and mostly used by webservices and web applications. Simple Mail Transfer Protocol (SMTP) is the protocol used by email servers for sending and forwarding email messages.

#### 2) Webservices

A webservice is a set of methods/resources provided by a software to another software by using web technologies. These web technologies may include communication patterns like REST (Representational State Transfer) which promotes systems interoperability or protocols like SOAP (Simple Object Access Protocol).

#### 3) REST API Authentication

Usually, in order to access webservices resources, authentication is required. The most common authentication mechanisms are OAuth 2.0 Tokens, JSON Web Token (JWT) and API keys. These mechanisms can be protected against *man-in-the-middle* attacks by using secure communication protocols like Hyper Text Transfer Protocol Secure (HTTPS).

#### 4) Existing Solutions API

Table 1 describes existing solutions API for sending messages, which includes recipient identifiers, protocols, authentication and delivery status verification methods. By observing this table, it is clear that ID and email are the most used identifiers for recipients and HTTP is the most used protocol. Tokens are frequently used to authenticate senders and delivery statuses are usually checked by response or webhooks.

Table 1 - Existing Solutions API Description

		Recipients Identifiers	Protocols for Sending Messages	Message Sender Authentication	Check Message Delivery Status
Solutions	SendEmail (SMTP)	email	SMTP	email, password	Delivery Status Notification (DSN)
	WhatsApp	phone number	HTTP	token	response, webhook
	Telegram	ID	HTTP	token	response
	Mattermost	ID	HTTP	token	response
	Twitter	ID	HTTP	consumer key and secret, token and token secret	response
	Facebook Messenger	ID, phone number	HTTP	token	response, webhook
	Twilio (as SMS Gateway)	phone number	HTTP	identifier, token	webhook

### III. SOFTWARE REQUIREMENTS

In this section, a list of all software requirements is presented.

#### A. External Interface Requirements

- 1) User Interfaces: user interacts with the system through a web application.
- 2) Hardware Interfaces: communication with hardware is done by means of existing software interfaces for that purpose, e.g. operating system, although adding a new channel may require a direct interface with hardware, e.g. SMS gateway interface.
- 3) Software Interfaces: the system interacts with applications that intend to send messages, an identity management system which allows users authentication in the web application, a group manager to identify members of message recipient groups, a database server to save system settings, channels to send messages and a file system to store messages attachments.
- 4) Communication Interfaces: HTTP protocol for web application, REST for webservice and any interface required to interact with database, group and identity manager, file system and channels.

#### B. Functional Requirements

- 1) User authentication in the web application.
- 2) Developer can integrate new channels in the system code.
- 3) Developer can add new channels.
- 4) Developer can view, modify and delete existing channels.
- 5) Administrator can add new applications.
- 6) Administrator can view, modify and delete existing applications.
- 7) Administrator can set an application permissions to: "none", which blocks its access to the API, "all", which allows auto approval on all application requests regarding senders permissions to send messages to groups and channels, and "requires approval", which makes these requests dependent on administration approval.
- 8) Application authentication in the webservice.
- 9) Application can make requests to add a new sender.
- 10) Administrator can approve an application request to add a new sender.
- 11) Administrator can view applications' senders.
- 12) Application can modify senders or delete them.
- 13) Application can view a list of groups.
- 14) Application can view a list of available channels.
- 15) Application can request sender permissions to allow them to send messages to a group.
- 16) Application can request sender permissions to allow them to send messages to a channel.
- 17) Administrator can approve an application request to add new sender's group permissions.
- 18) Administrator can approve an application request to add new sender's channel permissions.
- 19) User can add a contact for a channel
- 20) User can view, modify and delete their contacts.
- 21) Application can request to send a message.
- 22) System adapts received messages content to channels and send them through these channels.
- 23) System saves messages delivery statuses.
- 24) Application can verify sent messages delivery statuses.
- 25) User can view messages sent to them.

#### C. Non-Functional Requirements

- 1) Security and Access Control: the system must provide authentication and authorization mechanisms to the web application and webservice clients in order to restrict their access to unauthorized resources or functionalities, according to their permissions.
- 2) Reliability: the system must be consistent in all operations and fault tolerant.
- 3) Usability: the web application should provide an efficient and intuitive user experience.
- 4) Portability: the system must be able to be executed in any operative system.
- 5) Scalability: the system should provide horizontal scalability mechanisms.
- 6) Availability: the system should be available 99% of the time and support a simultaneous number of users in the order of magnitude of the number of members of the organization where it is used.
- 7) Robustness: transactions in the database must respect the ACID properties (Atomicity, Consistency, Insulation and Durability) and the system must deal with different errors, usually originated from invalid external inputs which must be all checked.
- 8) Openness: webservice interaction is done in REST and the system should provide mechanisms that ease the integration with group and identity managers.
- 9) Extensibility: the system must allow and ease the integration of new channels.

### IV. IMPLEMENTATION

The developed system's proof of concept (PoC) technologies, architecture, data model and API are described in this section.

#### A. Technologies

The main technologies used are Java SE Development Kit 8 and Tomcat 7 to execute the system. FenixEdu is the application providing the group and identity manager, OAuth 2.0 authentication mechanisms, Spring MVC to build the web application and webservice and Java Versioned STM (JVSTM) for database atomic transactions. JavaMail 1.6.2 is used for sending emails.

#### B. Architecture

System's architecture is described in Figure 1. Essentially, the Notifications System interacts with applications, browsers, group and identity management software and channels. Applications receive message sending requests from their users and forward these requests to the system via REST API. Then, the system accesses the group manager to identify the members of message recipient groups. System's users are the recipients and they can manage their contacts by accessing the web application through a web browser. Lastly, the system forwards these messages to channels and waits for delivery status notifications. The system can authenticate users by accessing the identity management software.

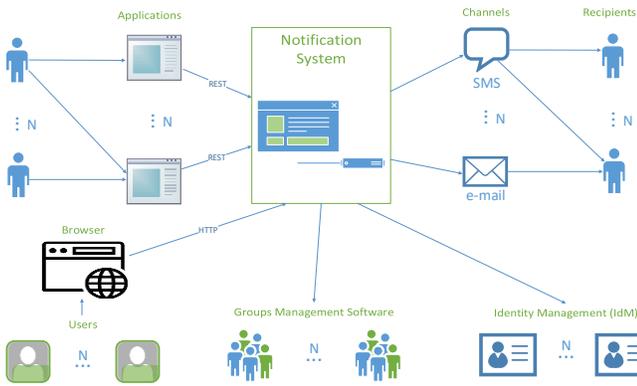


Figure 1 - System's High-Level Architecture

### C. Data Model

A data model of the system is presented in Figure 2.

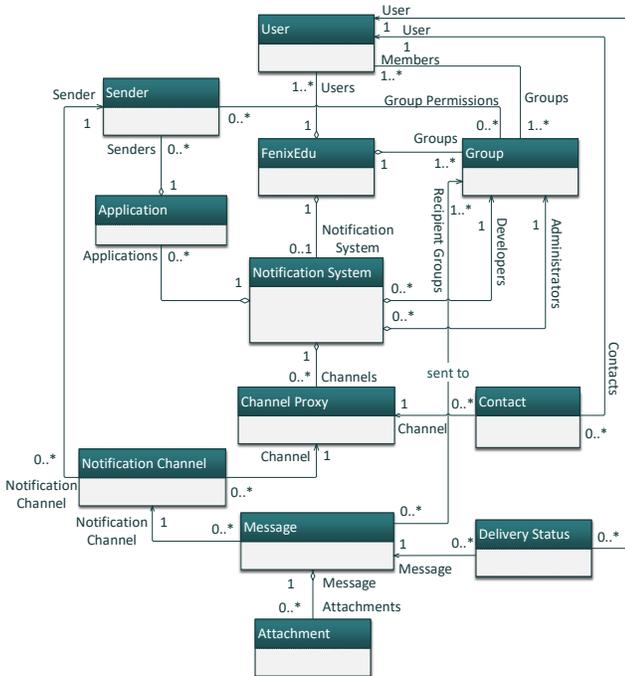


Figure 2 - Simplified System Data Model

### D. User Interaction

Users can interact with the system via web application. In this application, they can manage the system if they are administrators, otherwise they can only manage their contacts and view their messages. An administrator can manage applications, applications' senders and respective permissions, messages and contacts.

Developers can integrate new channels in the system by adding the new channel class to the project, recompiling and rebooting the system.

### E. Webservice API

The developed proof of concept provides a REST API interface to interact with applications. Its most important endpoints are presented in Table 2, which includes adding a new sender, giving them permissions to send messages to groups and channels, send a message and retrieve a message delivery status. Every endpoint returns information regarding system data or error messages, both in JSON format.

Table 2 - Webservice API

<b>~/applications/{applicationId}/senders</b>	
<b>POST</b>	Adds a new sender to an application. It requires a JSON containing sender's name.
<b>~/applications/{applicationId}/senders/{senderId}/grouppermissions</b>	
<b>POST</b>	Give group permissions to a sender, allowing them to send messages to that group. A JSON with group name is required.
<b>~/applications/{applicationId}/senders/{senderId}/notificationchannels</b>	
<b>POST</b>	Give channel permissions to a sender, allowing them to send messages to that channel. A JSON with channel name is required.
<b>~/applications/{applicationId}/messages</b>	
<b>POST</b>	Sends a message to groups via a channel. A FormData must be included containing a parameter called "json", a JSON containing recipient group names, notification channel and message content. A parameter called "attachment" can be used to include attachments.
<b>~/applications/{applicationId}/messages/{messageId}/deliverystatus</b>	
<b>GET</b>	Returns a JSON containing message delivery statuses.

### F. Channel Proxy API

The class Channel is abstract and it acts like a proxy for communication channels. When the developer wants to add a new communication channel to the system, he must create a class that extends the Channel class, which requires the implementation of the following methods:

- 1) void sendMessage(Message) - sends a message to a channel. A Delivery Status instance must be created for each recipient.
- 2) DeliveryStatus dealWithDeliveryStatusNotifications(HttpServletRequest request) - this method is invoked whenever a delivery status notification from a channel is received through the webservice. It is used to update Delivery Status instances.

### G. Security and Access Control

The web application requires users to authenticate with their email and password credentials. This way it is possible to identify their administration permissions and control the access to system resources. It means users with no administration permissions can only configure their contacts and view their messages. Administrators can access all system configuration menus except channels management menu. Developers can only access channels management menu. Applications must authenticate in the webservice using OAuth 2.0 in order to make requests to the available endpoints. This way an application cannot access other applications' data.

Concerning authentication in channel gateways, email requires email and password credentials which must be configured in the web application by the developers. Other channels mainly require access tokens to access them, which are also configured by the developers via web application.

## V. VALIDATION

In this section, it is given a brief description of how the proof of concept was used, a performance analysis and an overall analysis of the results.

### A. Proof of Concept

The proof of concept is a FenixEdu module. Its source code can be found at <https://github.com/riccor/notifcenter>. Command “*mvn clean install*” compiles the module. To run it, FenixEdu web application is required and can be found at <https://github.com/riccor/notifcenter-webapp>. Command “*mvn tomcat7:run*” executes the system.

Four channels were added as example: email, Twitter, Telegram and WhatsApp (via Twilio). Credentials to use these channels are required to make them available and can be configured in the web application.

This proof of concept includes all the requirements specified previously except: the functionality that allows administrators to approve sender permissions requests for channels and groups (they are automatically approved), fault tolerance mechanisms and high user experience quality on the web application. These requirements are not needed for demonstration purposes.

### B. Performance Analysis

Tests were made to perceive the impact of the proof of concept in message delivery times, since it acts like a proxy for communication channels. The results are presented in Table 3.

Table 3 - Performance Analysis using Channel Telegram

		Elapsed Time (s)	Impact (%)	
Tests	Direct	Send 250 messages sequentially	103.301 (reference value)	
	Notification System	Send 250 messages sequentially	72.161	≈-30%
		1 message for 1 group of 250 users	72.837	≈-30%
		1 message for 250 groups of 1 user each	73.167	≈-30%

By observing Table 3, it is clear that sending messages via this system has no impact on the delivery times. In fact, Spring MVC REST controller class is multithreaded, which makes the system to process messages sending requests about 30% faster. The time required to send 1 message to 250 groups of 1 element each is greater than the time required to send 1 message to 1 group of 250 elements due to the higher number of iterations

required. However, this difference is not significant, since the group manager is not external.

### C. Results

The developed proof of concept verified the applicability of the used methodology. The used technologies, architecture and data model allowed the creation of a Notification System capable of serving its purpose: efficient integration of communication channels into a computer system for sending messages through them, whose content is adapted for each channel. Solving issues concerning fault tolerance was not the purpose of this proof of concept, but they must be considered when developing this system for production environments, especially to assure message delivery, which is a complex task. Giving users the ability to choose from who they wish to receive messages is an useful functionality which can be easily included in this system without changing the proposed data model. Another important feature which may improve communication efficiency and not included in this proof of concept is the implementation of “meta-channels”. It requires changes in the data model and consists of a new entity representing a set of channels, e.g. urgent channels group, official channels group, paid channels group, recipients preferred channels group, etc.

The performance analysis shows that this system, which is essentially a proxy for communication channels, has no impact on messages delivery times. In fact, it speeds up the message delivering process, which means it is efficient.

In the context of school organizations, the relevance of this system was confirmed through surveys conducted to the Instituto Superior Técnico community. 65.5% of the respondents, essentially students, shows interest in using this system. 71.9% finds relevant to able to receive messages through multiple channels. They also show interest in receiving school messages via push notifications and instant messaging platform WhatsApp.

In May 2019, a meeting was held with two members of Instituto Superior Técnico’s Computer Services department, Eng. Sérgio Silva and Eng. David Martinho. Despite some technical improvements that have been suggested to be made on this system, especially the inclusion of a functionality which allows to confirm the personal contacts inserted by the users, they show interest in this system and find it relevant. They appreciate its ability to integrate with other applications such as the group manager. Being open source and easily extensible are other appreciated features. They also confirmed the difficulty in integrating communication channels in their IT systems and the high complexity required to ensure the delivery of messages. They were working on a push notification channel, which suggests the need for new channels adoption.

In Table 4, the system is compared with alternative solutions in terms of its main requirements. By observing this table, it is clear that the system meets a set of requirements not presented by the other solutions. The feature which allows to manage senders’ permissions is usually disregarded by the alternatives as well as the possibility to integrate new channels. None of these alternatives allows interaction with an external group manager.

Table 4 - Comparison with Alternatives

		Solutions			
		Notification System	MailClark	SendPulse	Regroup Mass Notification
Requirements	Sender channels/groups permissions management	✓	-	-	✓
	New channels integration	✓	-	-	? (3)
	Channels management	✓	✓	✓	? (3)
	Recipient contacts hidden from sender	✓	-	✓	✓
	API REST webservice	✓	-	✓	✓
	External group management software integration	✓	-	-	-
	User contacts management	✓	-	✓ (1)	? (3)
	Message content adaptation to channel	✓	-	✓ (2)	✓ (2)
	Message delivery statuses	✓	✓	✓	✓
	Open source	✓	-	-	-

(1) using subscription forms

(2) automatic message translation

(3) unclear

## VI. CONCLUSIONS

Communication efficiency is a crucial factor in the collaborative environment of organizations, just as it is in the relationship of companies with their clients. Technologies have provided many communication channels like social networks and instant messaging services, which are widely used and changed people's lives. Companies must adopt those technologies to stay closer to their clients in order to improve their success. A highly integrated solution like the Notification System eases that adoption.

There is a growing concern about the protection of personal data. GDPR has reinforced this fact. Offering people a service that allows them to insert and manage their personal contacts for the different existing channels and hide these same contacts from message senders is relevant. Choosing from which senders they want to receive messages is also an important feature as well as subscribing to message topics.

In the context of school organizations, the relevance of this system was confirmed through surveys conducted to the Instituto Superior Técnico community. It is expected that schools start adopting this type of service soon. Also, instant messaging services are currently the most relevant and most used communication channel by students.

Between 2017 and 2019 there has been an increase in collaboration solutions that allow the integration of modules/plugins offering many tools like multi-channel communication, which is exactly the purpose of this system. Microsoft Teams is an example that has seen significant growth in its adoption during this period [20].

Ensuring that a message reaches its destination in a timely manner is significant, especially in situations of danger or in a collaborative context. The Notification System maximizes this guarantee.

### A. Future work

In order to improve the system, it is recommended to study and implement the following solutions:

- 1) Message delivery assurance mechanisms.
- 2) "Meta channels", which allow messages being sent to multiple channels according to their urgency, recipients' channel preferences, etc.

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