



Cargomail — A Privacy-Aware Email System

Revision 2

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Abstract—Electronic mail (email) is the most pervasive form of business information exchange. Email is used not only as an interpersonal communication tool but also as a "default choice" for sending files.

This paper introduces Cargomail: a privacy-aware email system designed with the precept that the storage of email messages should be the responsibility of users and not of email providers.

Additionally, we explain the importance of separating the identifier (email address) and the locator (mailbox) in the design of the Cargomail architecture. Our paper concludes by highlighting the significant advantages of this design.

I. INTRODUCTION

The main components of the email system were designed between the early 1970s and mid-1990s by many inventors. Over time, email has become the most commonly used Internet application. Nowadays, email is the only ubiquitous communication system on the Internet that was built in a decentralized fashion. Moreover, the email infrastructure forms the backbone of the global digital identity.

II. CURRENT SITUATION

Today, outgoing email is typically transferred from the source system to the destination system as a single text-encoded file using the Simple Mail Transfer Protocol (SMTP). SMTP is an over-40-year-old push-based protocol, and even though SMTP has been updated, modified, and extended multiple times to increase security and efficiency, it still lags behind modern web-based protocols.

III. PROBLEMS AND ISSUES

Despite the importance of email infrastructure, the whole ecosystem still relies on more than 40-year-old architecture and protocol design. There have been spam and attachment issues from the very beginning. While conceptually sound as a communication means, the email system is structurally obsolete and functionally deficient.

A. Functional and Security Flaws

Even though the major email service providers claim their email services to be safe, the fact remains that fundamental security and functional flaws are not fixed. There is still a dichotomy of attachment delivery; bulky files are not transferred as an attachment but are shared via links. A "file sharing" is unnatural for the email system, where each message with attachments is expected to be time-consistent. Additionally, shared links can pose a consent phishing attack threat, where an attacker tricks users into granting malicious application access to sensitive resources.

B. Confidentiality and Privacy

Now, if we (as users) want to use a single email address, we have no choice but to use a single email service provider for all categories of communication. Information about every email we send or re-

ceive—"buying a car or a home, applying for a loan, taking out insurance, purchasing potato chips, requesting a government grant, getting turned down for credit, going to work, seeing a doctor" [1]—is funneled through the same service providers. This raises privacy concerns, leading to what we may call a One-Address-Fits-All privacy issue.

C. Hyperlinks to External Files

Documents, images, videos, and audio should be an integral part of the email. The concept of keeping a time-consistent, recipient-owned copy of the sender's files is critical in some industries. Here is the list of issues with hyperlinks to external files in email messages:

- expired, unknown, blocked, phishing, or malicious hyperlink
- masked hyperlink target using a URL shortener
- target updated - not the version it is expected
- target changed - forgery
- target encrypted - need a password
- access control - requires signup or sign in
- consent phishing attack

Given these points—You are buying a "pig in a poke" with each hyperlink to the external file in the email message.

D. Content Repository

The current email system is missing a content repository—a "file system on steroids" with the capability to create, store, locate, and exchange any content.

IV. PROPOSED SOLUTION

Given that the current email system is lagging behind modern communication and collaboration tools, we propose to build a "logistic" overlay on top of the existing email architecture to enhance the usability and security of the email system.

A. Goals and Objectives

At the core of the proposed solution is an attempt to improve email usability as an interpersonal communication tool and as the default choice to send and store files while supporting data sovereignty and governance. It is essential to ensure that the new architecture is interoperable with the existing email architecture to allow end-to-end communication between early adopters and legacy systems. Our goal is to ensure that the proposed solution can be deployed incrementally.

B. Concept

The current email system design defines an email address as a character string that identifies a user to whom mail will be sent or a location into which mail will be deposited. In that sense, the terms mailbox and email address can be used interchangeably. However, Cargomail

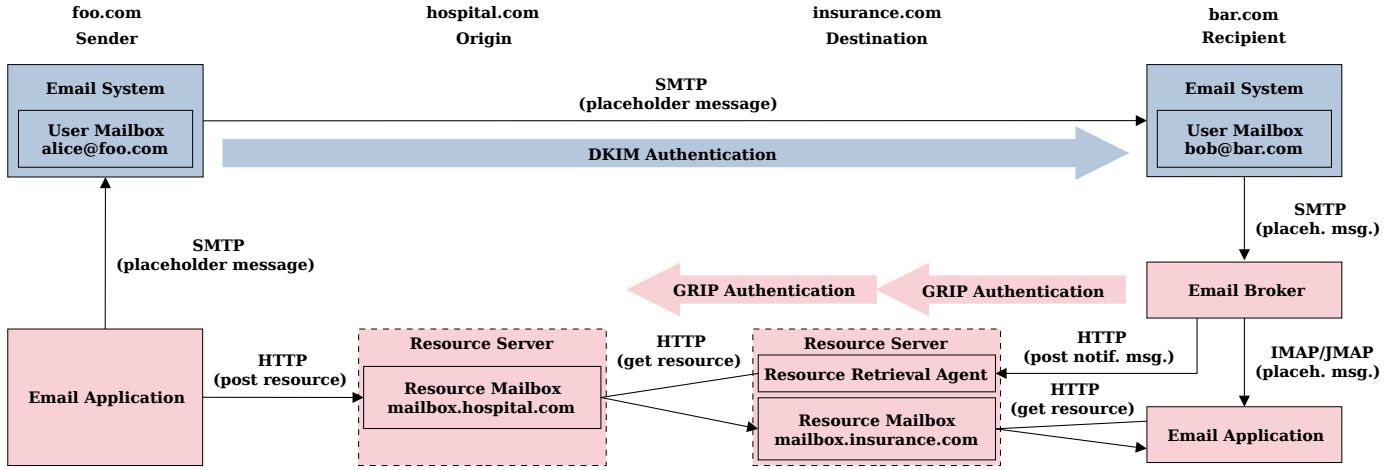


Fig. 1. Cargomail architecture

uses a different architecture that separates the identifier and the locator of the address/mailbox tandem to introduce a new type of mailbox—a resource mailbox. While the actual correspondence takes place between the resource mailboxes, the default user mailbox of the email system is used for placeholder messages, as shown in Figure 1. To reference email resources, Cargomail uses content-addressed identifiers instead of URLs, as the location of the resources differs between the sender and recipient.

The approach depicted in Figure 1. separates the identifier (the email address) and locator (the resource mailbox URL). By decoupling the locator and identification, data can be exchanged between designated resource mailboxes using individual user email addresses. Cargomail exchanges referenced resources between resource mailboxes using the Global Reference Identity Protocol (GRIP) [2] authentication mechanism. This enables both the sender and recipient to use multiple resource mailboxes while still using their single email address.

Moreover, Cargomail does not use attachments or links to external files. Instead, it uses an editor that allows users to reference documents, images, and videos in the message body by their content via a cryptographic hash value while keeping the respective resources in a content-addressed resource mailbox. The final download link is constructed in the email client using the destination resource mailbox Uniform Resource Locator (URL) and the cryptographic hash value of the referenced resource delivered on the placeholder message, see Figure 2. The content of the email resource can be displayed directly in the message body.

C. Key Points

- Each email consists of resources (message and referenced files) stored in the resource mailbox—on the email-specific resource server.
- The email resources owned by the sender, stored in an origin resource mailbox, are temporarily shared with recipients. Following a successful sharing process, a placeholder message is sent to each recipient through the standard email system. The placeholder message contains the origin resource mailbox URL, the cryptographic hash values of the referenced resources, and the category of correspondence, e.g., personal, business, or healthcare, as illustrated in Figure 2.
- After receiving the placeholder message, the recipient's email broker determines (according to the user's preferences and the category of

correspondence) which destination resource mailbox will be used for communication. After the destination resource mailbox determination, the email broker creates the notification message with the origin resource mailbox URL and the cryptographic hash values of the referenced resources and posts it to the relevant destination resource server using the GRIP authentication mechanism. Then the email broker adds the destination resource mailbox URL header to the placeholder message and delivers it to the email application using IMAP or JMAP protocol.

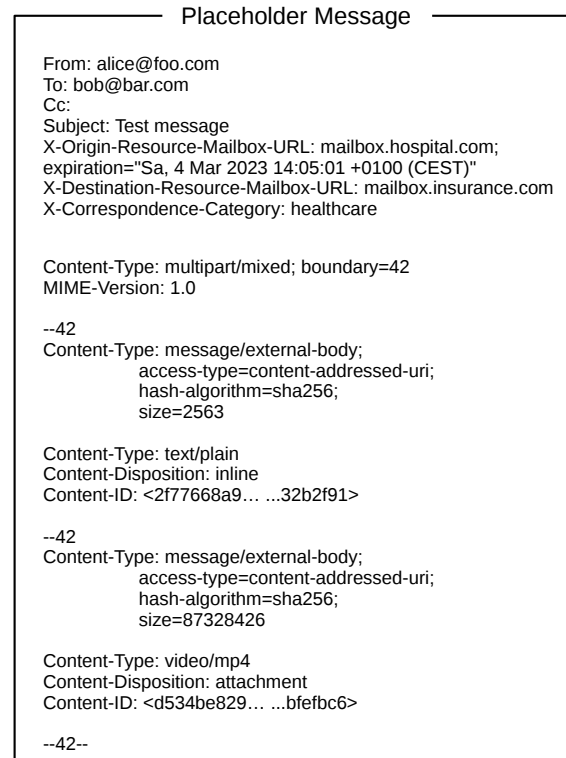


Fig. 2. Placeholder message

- The resource retrieval agent at the destination resource server gets the origin resource mailbox URL and the cryptographic hash values of the referenced resources in the notification message. Using the GRIP authentication mechanism, the agent tries to retrieve the email re-

sources from the origin resource mailbox. After successful authentication, the data is retrieved and stored in the destination resource mailbox. Finally, according to the placeholder message template, the email application downloads the relevant data stored in the destination resource mailbox and reconstructs the original email.

D. GRIP Authentication

GRIP is a token-based security protocol that authenticates service requests between untrusted hosts across the Internet. We use self-issued DNS-bound tokens to propagate user/service context from the email broker service to the destination resource server and from the destination resource server to the origin resource server, all in different trust domains. It is crucial to ensure that tokens are properly chained/nested to convey relevant user/service information from one service to another.

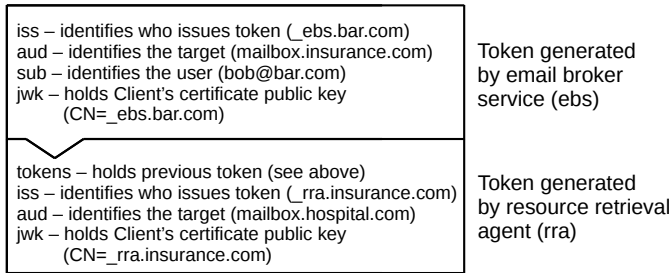


Fig. 3. Nested, chained, self-issued DNS-bound tokens

This zero-trust authentication mechanism enhances the usability and security of the proposed Cargomail system.

V. ADVANTAGES COMPARED TO THE CURRENT EMAIL SYSTEM

Cargomail has several decisive advantages over the current email system.

A. Spam Protection

With Cargomail architecture, the email address and mailbox are separated. The actual email correspondence is exchanged between the resource mailboxes, or "locators," while the email address, or "identifier," is only used to deliver the placeholder messages. This architecture does not protect against unsolicited emails—anyone can send you an email—it allows for a more detailed assessment of the sender's reputation by individually evaluating their email address identifier and mailbox locator.

B. Data Sovereignty

The resource mailbox is decoupled from the user's email address. This separation allows a user with a single email address to use multiple resource mailboxes side by side. With a single email address and numerous mailboxes, Cargomail can keep official, business, healthcare, and personal correspondence separately on designated resource servers, ensuring compliance with relevant laws and regulations.

C. Data Governance

Messages and their resources are kept together in chronological tamper-resistant records. A resource mailbox ensures the authenticity and integrity of email messages and their resources. The cryptographic hash value guarantees the storage of only a single instance of a resource. With the capability to create, store, locate, and exchange any content, including documents, images, videos, and audio, the proposed

solution is a promising foundation for a data governance framework.

VI. IMPLEMENTATION CONCERNS

This section deals with the issues of implementing the proposed data exchange mechanism into the existing email infrastructure.

A. MIME External-Body Subtype

Cargomail uses the MIME 'message/external-body' subtype in the placeholder message to indicate that the actual body data are not included but merely referenced. Although this is a standardized method of referencing external data, not every email provider handles it correctly.

B. Decentralized Notification System from Scratch

Instead of relying on an SMTP-based email ecosystem, a new web-based decentralized notification system that utilizes the GRIP authentication mechanism for sending placeholder messages may be worth considering.

VII. MODELS AND SCENARIOS

Although Cargomail can be integrated into the email system of any email service provider, we slightly digress to introduce two visionary models of what a global email ecosystem might look like in the future.

A. Estonian Model

In this model, the government provides email services with user mailboxes. To avoid the risk of governmental surveillance, Cargomail allows citizens to use non-governmental resource mailboxes, e.g., from financial institutions or healthcare providers. Using non-governmental, sector-specific resource mailboxes increases the privacy of individual citizens, as the government cannot obtain detailed information about their activities.

B. Postal Model

According to UPU research [3], more than 93% of postal operators provide some form of digital postal service either directly or in partnership with other companies. Cargomail allows postal operators to expand and become public email service providers or innovate their existing email services and provide the user mailbox services with the ability to attach the resource mailboxes from the government as well as other institutions and organizations.

VIII. CONCLUSION

Cargomail can play an essential role in communication across various industries in the public and private sectors.

A. Overall Summary

Combining Cargomail with the current email system creates a hybrid architecture that meets the needs of a modern communication tool. Exchanging data between the relevant mailboxes eliminates privacy concerns.

B. Future Work

Cargomail brings content-addressed storage and a new data exchange mechanism into the email ecosystem, predestining the proposed system to become more than a bare messaging tool. It would be fascinating to build a prototype of the proposed solution to serve as a proof of concept.

IX. DISCUSSION

While this proposal seems closely related to the Internet Mail 2000 [4] concept proposed by Daniel J. Bernstein, we differ in the new idea that the storage of email messages and their resources should be the responsibility of users and not of email providers.

REFERENCES

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- [2] I. Zboran, "Global Reference Identity Protocol (GRIP)," GitHub repository, March 2023, <https://github.com/cargomail-org/grip>.
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- [4] Internet Mail 2000, accessed 23 April 2023, https://en.wikipedia.org/wiki/Internet_Mail_2000.