Matrix: An open network for secure, decentralized communication

Sumner Evans

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Beeper

A bit about me

- I graduated in 2018 with my bachelor's in CS from Mines.
- I graduated in 2019 with my master's in CS, also from Mines.
- I worked at The Trade Desk for two years right after graduating.
- I currently am teaching *CSCI 400 Principles of Programming Languages* and I have previously taught *CSCI 406 Algorithms* and *CSCI 564 Advanced Computer Architecture*.
- I started at Beeper in July.

A bit about you

I’d like to get to know everyone a bit more and get a feel for everyone’s experience levels.

- How many of you have taken Algorithms?
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- How many of you have taken Intro to Computer Science?
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Overview

1. Why Matrix?
2. What does Matrix provide?
3. How does it work?
4. What does Beeper do?
5. Things that I’m excited about in Matrix
6. How to get involved with Matrix
7. A few general tips for everyone

Why Matrix?

Let’s talk about chat platforms…

Which of the following chat networks do you use/have you used?

- SMS/MMS
- iMessage
- LinkedIn
- Snapchat
- WhatsApp
- Instagram
- Discord
- Facebook Messenger
- Hangouts
- Slack
- Microsoft Teams
- Signal
- Telegram
- Wire

What do all of these chat networks have in common?

They are **non-interoperable, and many are closed source and/or unencrypted**.

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The **closed source** platforms are problematic because you can never be sure *how your data is being used*.

The **unencrypted** platforms are problematic because your messages are not private.

And, because none of them are interoperable, you have to have a ton of chat apps on your phone.

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What does Matrix provide?

Matrix solves all your problems

Matrix is an **open** specification for **encrypted**, **decentralized** communication.

It is also designed in such a way that it makes it easy to break down walled garden communication platforms via **bridging**.

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A side note

I first became interested in Matrix when I was the incoming Chair of ACM. Robby (VC) and I tried out most of the open source chat platforms and ended up landing on Matrix because it had all of these characteristics.

Matrix is an *open specification*

Open specifications and standards are all around you. They just make sense™.

Examples:

- Power plugs
- USB
- Wi-Fi
- Every crypto algorithm that's any good

Open protocols allow for *open development* and *clean-room implementations*, they *encourage competition*, and are *externally auditable*.

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Matrix is *encrypted* by default*

Matrix has encryption built-in. It is implemented using Olm, which is a clone of the Signal protocol

Matrix is *decentralized*

The Matrix architecture is actually a *federated* architecture.

Individual devices communicate to a *homeserver* which anyone can host.

The homeserver communicates with other homeservers in the federation.

Think of it like email. You can email somebody using Outlook from Gmail.*

Every server in the federation gets a copy of a room, so no one entity controls the network.

This also means that the network is resilient to individual server outages, or even wider internet outages.

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Bridges bring external chat networks into Matrix. More on this later.

Bots allow for automated interactions and notifications.

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How does it work?

Architecture

Every server has a copy of the room, but how do we keep that in sync?

The architecture of Matrix does this in a way that ensures *eventual consistency*.

Even if the server where the room was created goes down, people can still communicate.

When a broken server comes back online, it will receive all the *events* (messages).

Let's look at the animation on Matrix.org...

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Client-Server API

The **Client-Server API** specifies how clients communicate with their homeserver.

Demo!

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Demo!

Federation (Server-Server) API

The **Server-Server API** or **Federation API** specifies how servers communicate with other servers to ensure that everyone has the same room state.

A bit of graph theory

- A **graph** is a collection of *nodes* connected by *edges*.
- A **directed graph** is a graph where the edges are *directional* (have arrows).
- An **acyclic graph** is a graph that has no cycles/loops.
- A **directed acyclic graph (DAG)** is a directional graph with no cycles.

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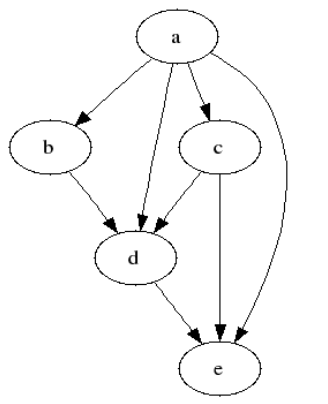

The event DAG

Matrix rooms are represented by a DAG of *events* representing things such as messages, joins, leaves, etc.

The DAG provides a *partial ordering* of events in the room because every event has zero or more “parent” events.

This is similar to Git where every commit has 0 or more “parent” commits.

See `https://matrix.org/docs/spec/#event-graphs`

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Event types

There are two main event types: **message events** and **state events**.

Message events:
These describe transient 'once-off' activity in a room such as an instant messages, VoIP call setups, file transfers, etc. They generally describe communication activity.

State events:
These describe updates to a given piece of persistent information ('state') related to a room, such as the room's name, topic, membership, participating servers, etc. State is modelled as a lookup table of key/value pairs per room, with each key being a tuple of `state_key` and `event type`. Each state event updates the value of a given key.

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What does Beeper do?

Things that I’m excited about in Matrix

* Obviously excited about bridges * Excited about possibilities with bots * Excited about possibilities of building on top of Matrix. For example, matrix notepad and matrix board * Excited about spaces and the potential for better community management

How to get involved with Matrix

A few general tips for everyone