ANR-PMR Health PPML workshop

Towards a hospital-friendly communication module

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1. Context and motivations

2. Communication design

3. Technical solutions

4. Few recommendations

Who am I?

- Computer engineer (graduated from UTC, Compiègne) specialized in Data Mining/Engineering but with professional experience in cybersec.
- This presentation exposes few of the results of the internship I did at Inria (Decentralized Secure Privacy-Preserving Surveying for Mobile Devices)
- Currently: *PhD student* between Inria Lille (Magnet) & University of Twente (Services, Cybersecurity and Safety group)

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Tailed library

- Tailed: Trustworthy AI Library for Environments which are Decentralized
- *Goal*: develop a cross-platform framework to deploy federated learning with user trust: learning contracts, verifiability, auditability, etc.
- Communication module studied in the context of Tailed
- $\Rightarrow$ we present our conclusions but *no strong claims*

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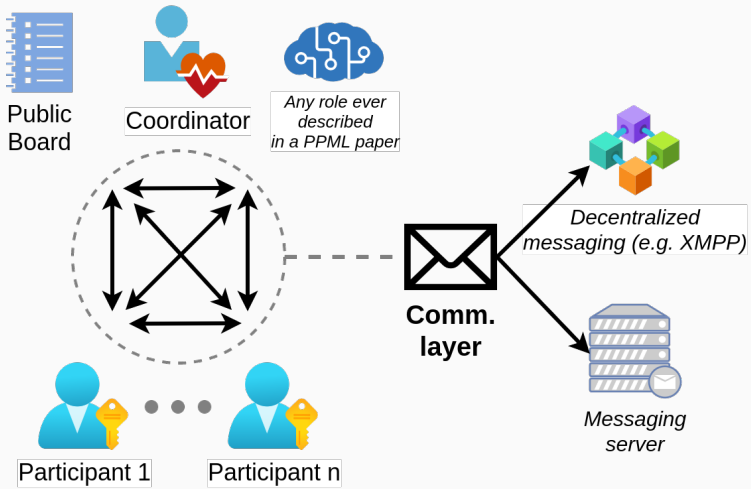
Quick vocabulary overview: roles in PPML protocols



NB: an agent can have several roles
e.g. public board + messaging server

Motivations

- *General goal*: make the communication technically possible between all the agents involved in a PPML protocol [not studied in the ML community]
- *Particular focus*: have a *hospital-friendly* communication system
- ⇒ *constraints*: possibly restrictive firewalls, minimize the permissions needed, avoid deploying something in their DMZ, minimize the setup/configuration cost, not only Linux servers, etc.
- *Perspectives*: build an OS-independent solution. Windows for hospitals but also Android and iOS to work on projects involving mobile users

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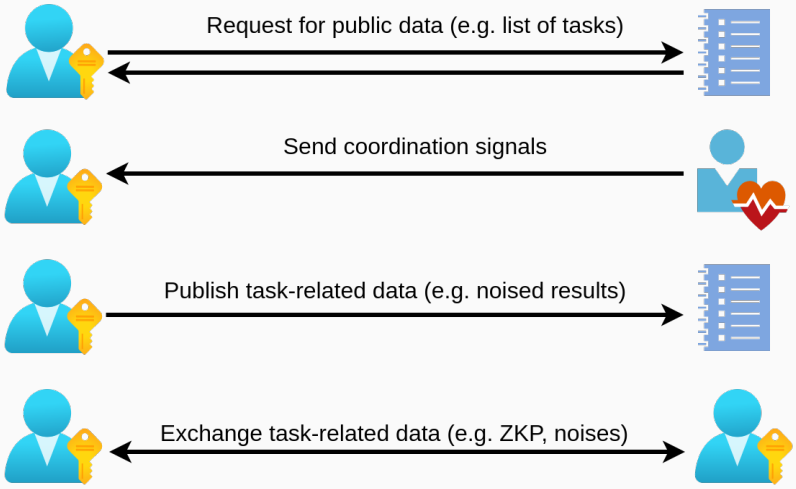
Communication requirements



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Communication centralization

- Everything cannot be addressed *easily* via decentralization: identity authority, public bulletin (e.g. to publish learning tasks), etc.
- Distributed ledgers, XMPP, etc. interesting but … messaging server = less costly and *easier deployment* (i.e. doesn't require n independent nodes)
- Centralization $\not\Rightarrow$ Trusted server (public keys, gossip, etc.)
- Communication centralization $\not\Rightarrow$ Learning centralization

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P2P limitations

- 1. *Cost*: requires some communications to set up a P2P channel ⇒ not worth it to set up a channel for only one message
- 2. *Trust model*: P2P protocols such as WebRTC require a central server to set up the communication ⇒ if the server is not trusted, requires public key infrastructure (PKI)
- P2P advantage: secure/private against honest-but-curious adversary
- Both P2P and centralized communications require a PKI to be secure against malicious server

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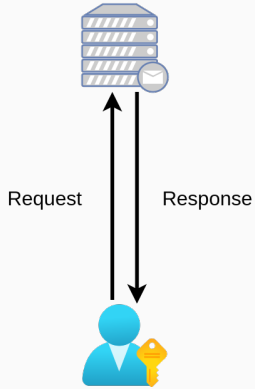
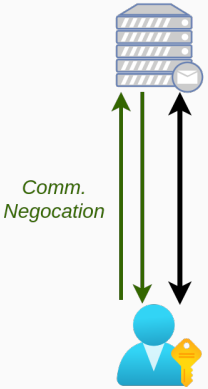
Communication paradigm: request-response vs. bidirectional



Request-response paradigm
(e.g. HTTP)



Bidirectional paradigm
(e.g. WebSockets)

Well-suited for
PPML requirements

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Overview of communication protocols

- We will *present and compare* the following protocols: HTTP polling, Server-sent events, sockets, WebSockets and HTTP2

- Focus on popular and widely implemented *client-server* protocols

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Comparison of the communication protocols: the veterans

- *HTTP polling* | **Pros**: compliant with any kind of (client) security policies | **Cons**: not very optimized
- *HTTP long polling* | **Pros**: compliant with any kind of (client) security policies | **Cons**: not very optimized and quite ”dirty”
- *Server-sent events* | **Pros**: compliant with old systems | **Cons**: outdated AND only allows server to client messages ($\Rightarrow$ should be combined with HTTP)
- *Socket communication* | **Pros**: tailor-made solution | **Cons**: very complex to implement (+ security risks!)

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Comparison of the communication protocols: the newcomers

- *WebSockets* | **Pros**: real-time bidirectional communication, available in most of the major web frameworks | **Cons**: no major WebSockets-specific framework has survived over time ⇒ no guidelines to use it properly

- *HTTP2 (+ gRPC)* | **Pros**: allows request-response as well as bidirectional communication (≈ HTTP1 + WS), gRPC is a rich framework | **Cons**: younger (⇒ less supported for now)

- **Summary**: for convenience purpose, HTTP2 (or WebSockets) seems to be a natural choice. For maximum compliance, HTTP polling is interesting.

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Introduction to asynchronous programming

- Motivation: *optimize waiting times* by creating a sort of concurrency in the execution while avoiding the cost of massive multithreading.
- Useful in *network* (especially bidirec. comm.) and file system interactions.
- *Async-await* paradigm: has a synchronous-like structure with simply ”await” keyword before blocking statements. For example: *await server.connect()*
- Async-await available in: C#, Python, JavaScript, Nim, Rust, C++20, etc.
- Even it looks like sync code, it requires *designing differently* the programs because of concurrency: events won’t always happen in an expected order

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How to choose a library?

- *Quality*: maturity, reputation, SSL support, Autobahn test result for WebSockets lib, etc.
- *Convenience*: how quick and easy will be the coding? Is there a framework? (protocol implementation $\neq$ framework)
- *Performances*: TechEmpower Framework Benchmarks. Perf.-convenience trade-off $\Rightarrow$ 1M req/sec is cool but not useful to everyone
- Number of protocols supported.
- Only choose a protocol if it has a good library in your language $\Rightarrow$ good theoretical properties are not enough!

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Security considerations

- *SSL/TLS*: the fundamental *must-have* (reminder: prevents eavesdropping)
- *Firewall policies*: some hospitals could filter protocols such as WebSockets. Minimum risk is obviously HTTP. HTTP2/gRPC could be preferred by some hospitals compared to WebSockets.
- *Message encryption*: SSL is not sufficient $\Rightarrow$ find an adequate PKI to encrypt agent-to-agent messages

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Concluding thoughts

- Prefer using only *one communication server*: more optimized and an easier (and more realistic) deployment especially for scenarios involving hospitals
- Prefer supporting *several comm. protocols*: WebSockets, gRPC, HTTP polling $\Rightarrow$ compliant with ”any” firewall.
- *Under development*: OS-independent communication module creating an abstraction of the protocol APIs $\Rightarrow$ user can focus her attention on the ML
- Studied only the communication level, but there are other *open questions*: cryptography, identity, scalability, etc. $\Rightarrow$ will be explored during my PhD

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Questions?