Towards Secure and Leak-Free Workflows Using Microservice Isolation

Loïc Miller, Pascal Mérindol, Antoine Gallais and Cristel Pelsser

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University of Strasbourg, France

Preventing workflow data exposures with microservices

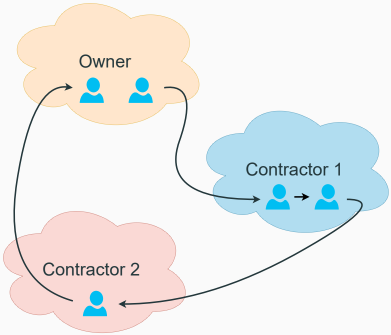
- There are more and more **data leaks and breaches**.
- They result in important **losses** for businesses.

- Yahoo (2013): 3 billion account details leaked.
- Unencrypted data accessed by an unauthorized third party.

- MikroTik routers hijacked (2018).
- Eavesdropping on $> 7,500$ routers.

Workflows

- We define a workflow as a *sequence of tasks* processed by a set of actors.
- The instigator of the workflow, the *owner* of the data, interacts with *contractors* to realize a task.
- Actors have *agents*: either an employee or a fully automated service.



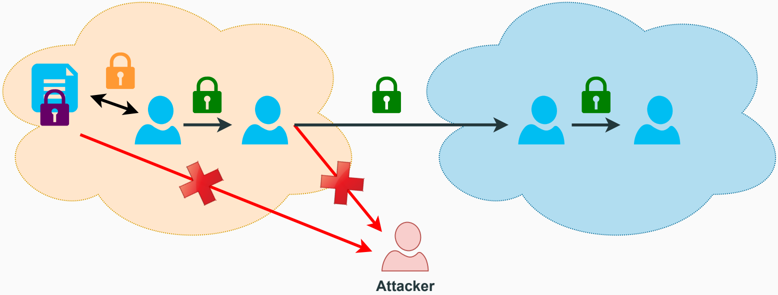
Objectives

How can we enforce a given workflow, which guarantees *data security at rest* and *in transport*, and *prevents data leaks*?

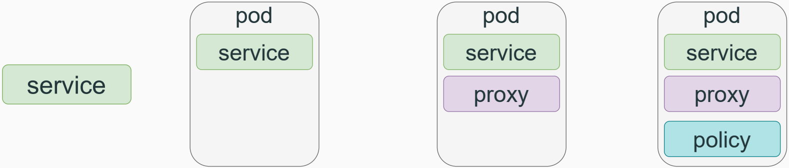
Desired properties

- Data security at rest: stored **encrypted**, access restricted by **isolation** and **policy**.
- Data security in transport: exchanged **encrypted**, with integrity and **authentication** checks.

The data cannot be **leaked** in both cases.



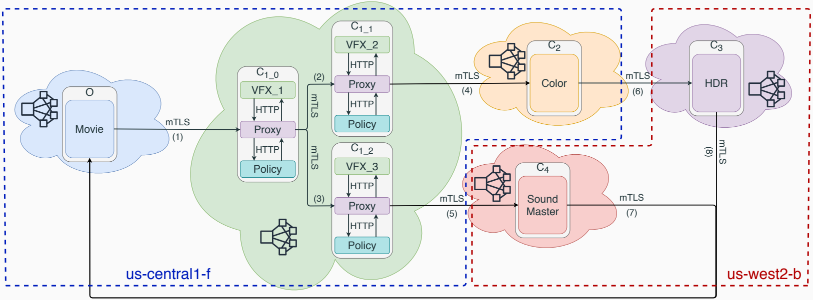
Building block security properties



Service	Orchestrator	Service mesh	Policy engine
Isolation	Isolation Encryption (at rest)	Identity & Authentication Encryption (mTLS)	Authorization

Encrypted storage, encrypted communications, policy enforcement.

Proof of Concept deployed on Google Cloud Platform



- One Kubernetes cluster per actor (5 in total).
- One n1-standard-v2 per cluster (2 vCPUs, 7.5 GB of memory), except the owner which has two.

Overhead of Security

How do we estimate the security tradeoff: Measure two metrics, pod startup time and request duration.

Effect of OPA on pod startup time

- Independent-samples t-test
- Two deployments: one with OPA and one without.
- 130 observations per pod ($N = 1820$).

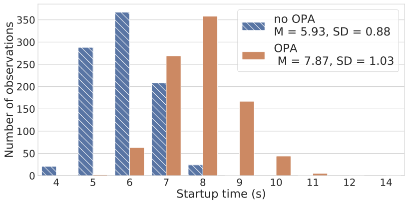
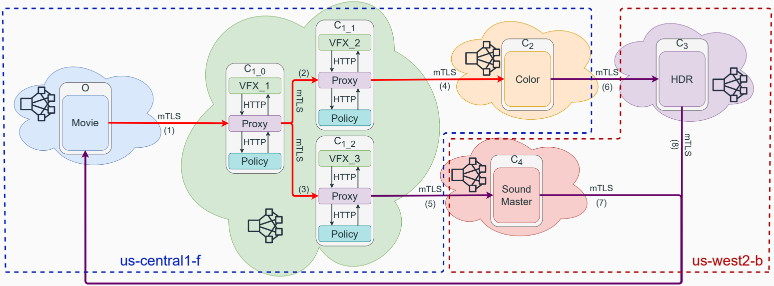


Figure 1: Startup time distribution

Time increased by **2 seconds on average (32.72%)**.

- $t(1818) = 43.19$, $p < 0.001$
- High effect size: $d = 1.985$
- High statistical power: $1 - \beta = 0.999$

Effect of policy size on request duration



We analyze **intra-region** and **inter-region** communications.

One-way between subjects ANOVA.

40 observations per communication per scenario ($N = 1600$).

Policy scenarios: `no opa`, `all allow`, `minimal` ,+100 (+147%), +1000 (+1470%).

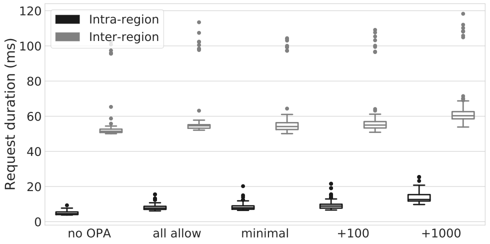
High (low) impact on intra (inter) region request time

Intra-region

- $F(4, 795) = 364.05$, $p < 0.001$
- **High** effect size: $\eta_p^2 = 0.65$

Inter-region

- $F(4, 795) = 15.23$, $p < 0.001$
- **Low** effect size: $\eta_p^2 = 0.07$



- **Significant difference in request duration between the five scenarios for both types.**

Conclusion

- Flexible infrastructure to secure communications in a workflow.
- Proof of concept[1].

Performance analysis

- Startup time using OPA increased by **2 seconds** (32.72%).
- Request duration is an important factor in intra-region communications.

[1] Code, data and guidance at https://github.com/loicmiller/secure-workflow

Thank you!