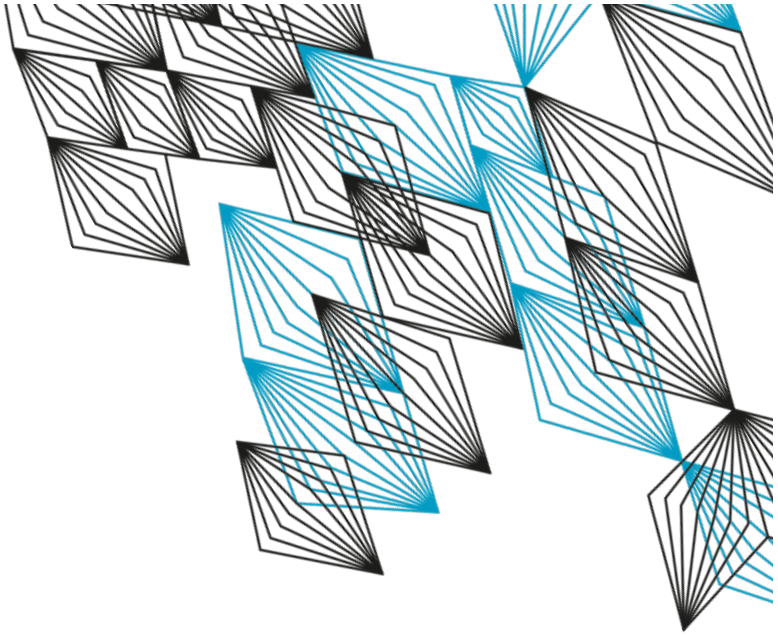
USER-DRIVEN PATH VERIFICATION AND CONTROL FOR INTER-DOMAIN NETWORKS



PROGRESS MEETING #1

RODRIGO, LEONARDO, PAOLA, AIKO, CRISTIAN

JULY 1, 2021

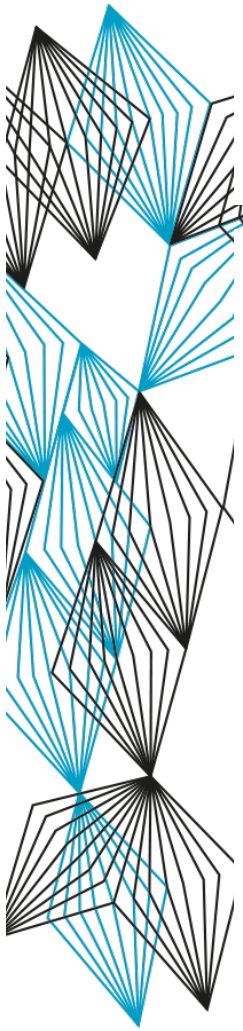
This research received funding from the Dutch Research Council (NWO) as part of the UPIN project

TODAY'S GOAL

- Recap of UPIN
- Update on status and future work
- Get your feedback

- Result: further improve researchers' work based on your feedback

PROPOSED AGENDA



10:00	Opening (Cristian)
10:00	Recap UPIN (Cristian)
10:10	Overall status (Cristian)
10:20	Progress path control (Leonardo)
10:40	Progress path discovery and verification (Rodrigo)
11:00	Discussion (All)
11:30	Partner presentation (optional)
12:00	Adjourn (Cristian)

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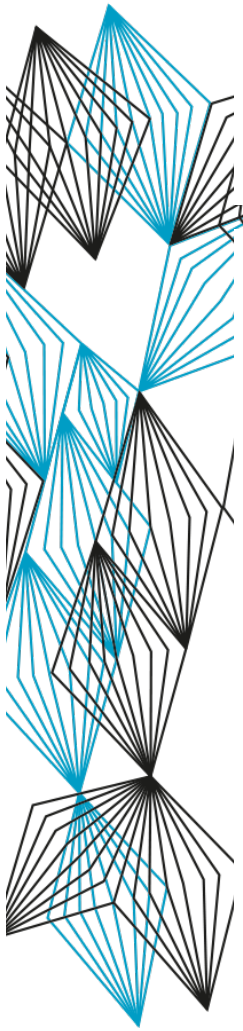
PROBLEM: DATA AUTONOMY “IN TRANSIT”



- Lack of **transparency** and **control** of how users’ data flows travel across the Internet
- Which network operators handle my data? How secure are their routers? I only want to use security-audited networks!
- Security risks for **critical services** like remote controlled healthcare robots, energy grids, intelligent transport systems

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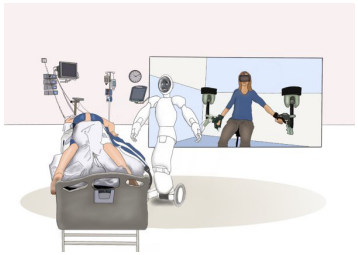
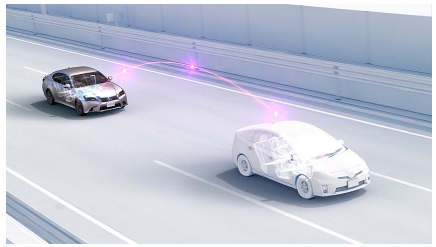
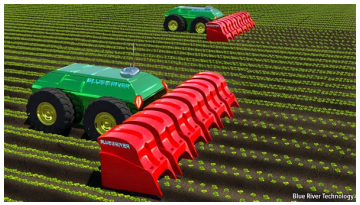
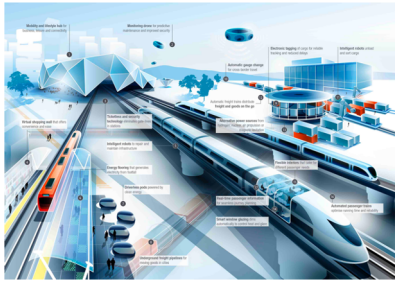
Reduced trust in the Internet infrastructure

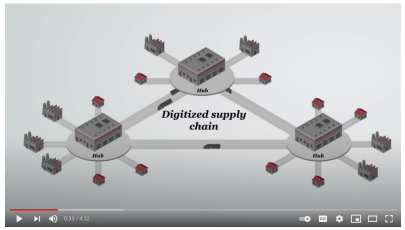
USE CASES: CRITICAL SERVICES

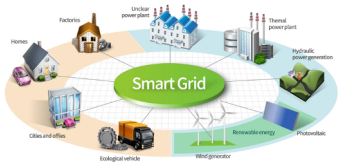












UPIN focus: health, IoT, Intelligent Transport Systems

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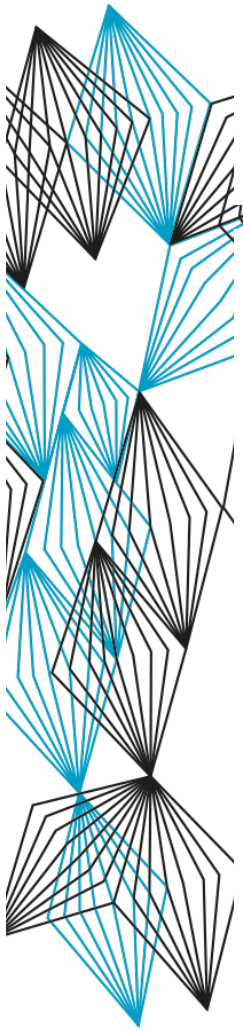
UPIN GOAL

Provide the building blocks that enable users (e.g., individuals and organizations) to control and verify how their data travels through the Internet or other types of large-scale inter-domain networks, both in terms of hops as well as routers traversed

Increase data autonomy in transit

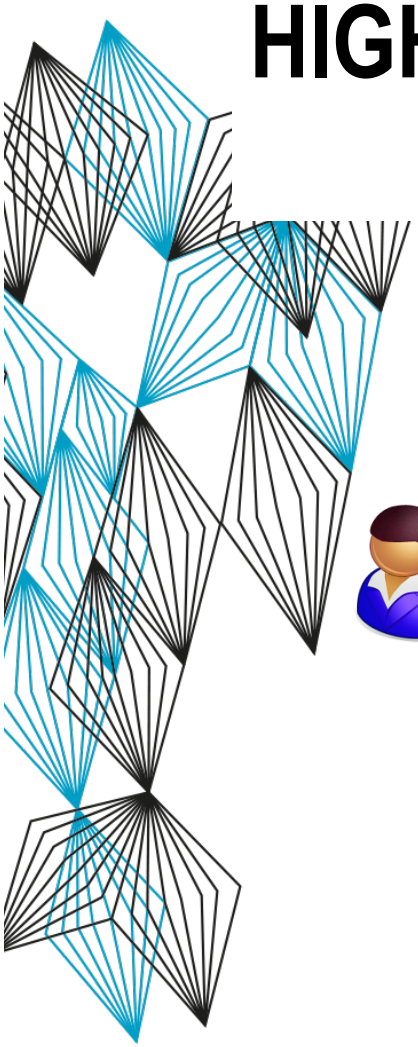
RESEARCH QUESTIONS



- Which mechanisms do we need to make the Internet more transparent and provide Internet users with more control over and verifiability of network paths in a scalable way?

- To what degree can the current Internet architecture accommodate these functions and which other emerging inter-network architectures might potentially be more suitable?

HIGH LEVEL APPROACH



Type of path specification:
- Routers: source code quality, composition & make, geoloc, etc,.
- Operators: available telemetry and VNFs, history of management operations, jurisdiction, etc.

Path control:
- Enforce path attributes by operations on data in transit
- Using Network Virtual Functions (NVF) and Segment Routing (SR)

Path verification:
- Obtain trustworthiness attributes of on-path routers and hops
- Assess trustworthiness of the path based on attributes (attestation)

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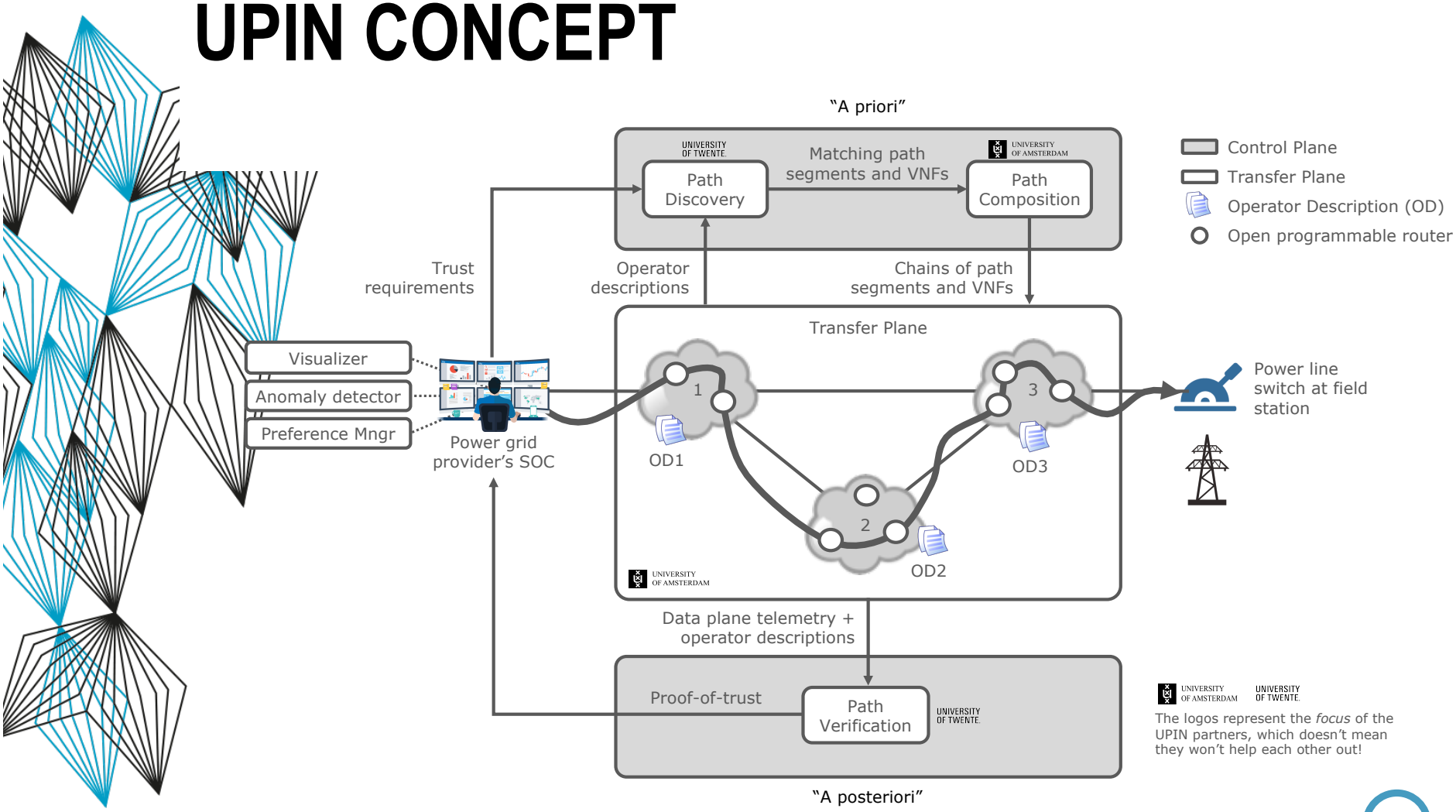
INNOVATIONS

- Novel inter-domain mechanisms for path control and verification based on user's trust requirement
- New data and control plane protocols that implement these mechanisms using programmable routers and SDN
- Evaluation of the performance and expected scalability of the UPIN system using the 2STiC testbed

UPIN CONCEPT



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The logos represent the *focus* of the UPIN partners, which doesn't mean they won't help each other out!

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KEY RESULTS

- System design and open-source implementation
- Evaluations of through use cases on 2STiC testbed
- Demonstrators of the UPIN concept
- Academic and other publications, annual workshop

TARGETED IMPACT

- Increased **user** control over data in transit
- Enable new types of network and service **operators**
- Advance emerging **standards** (e.g., path-aware networking)
- Increased **pool of knowledge** of academic and operator communities

STATUS

- Poster presentation at ICT.Open (Nov 2020)
- Accepted work-in-progress paper TAURIN workshop (Jun 2021)
- First path control experiments at the UvA
- Website: https://upin-project.nl (work in progress)
- More details in Rodrigo's and Leonardo's talks

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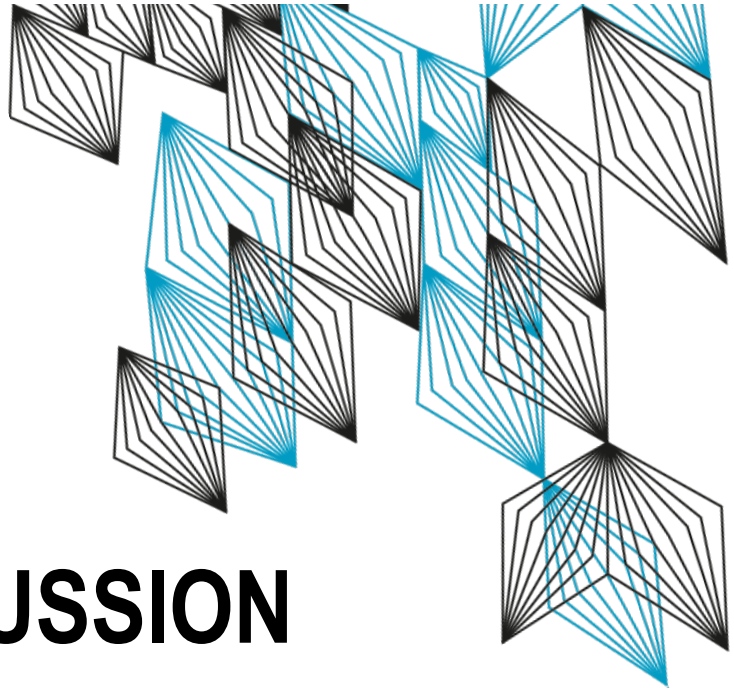

QUESTIONS AND DISCUSSION

This research received funding from the Dutch Research Council (NWO) as part of the UPIN project

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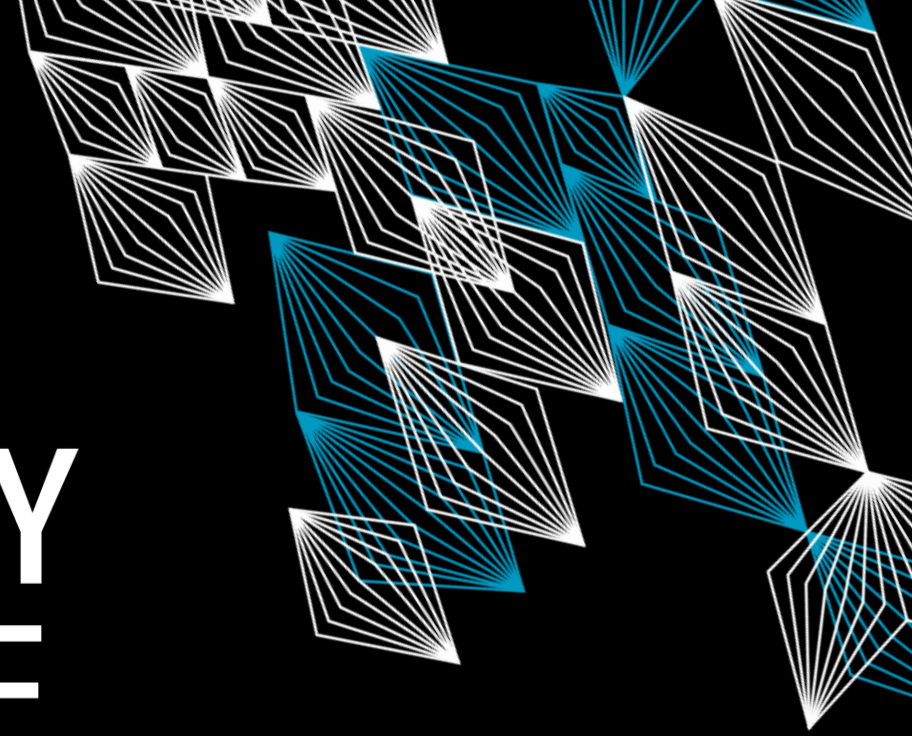

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UPIN PROGRESS MEETING

00. SUMMARY

SUMMARY

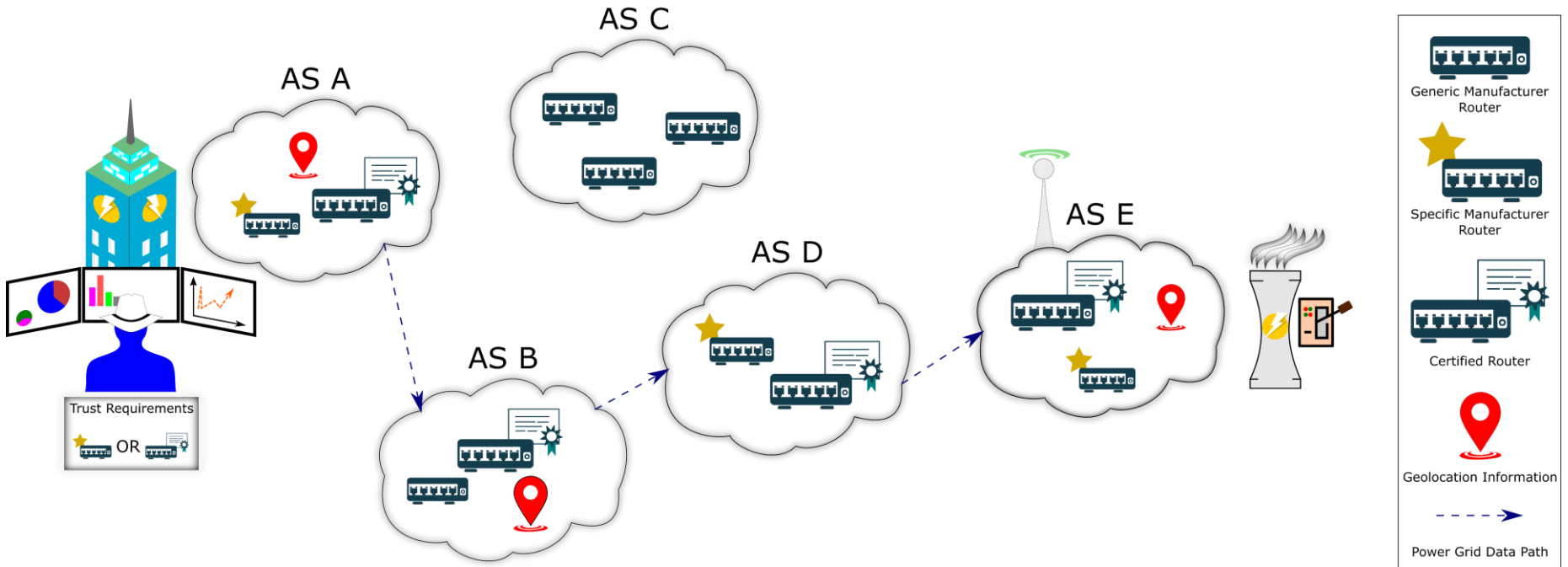
1. Power Grid Use-case
2. Existing Technologies Review
3. UPIN Software Architecture
4. Path Verification Experiments
5. Requirements and Users Surveying

01. POWER GRID USE-CASE

POWER GRID USE CASE

- Decentralized Power Grids will become highly dependant on the security of the network since they will likely depend on multi-domain networks

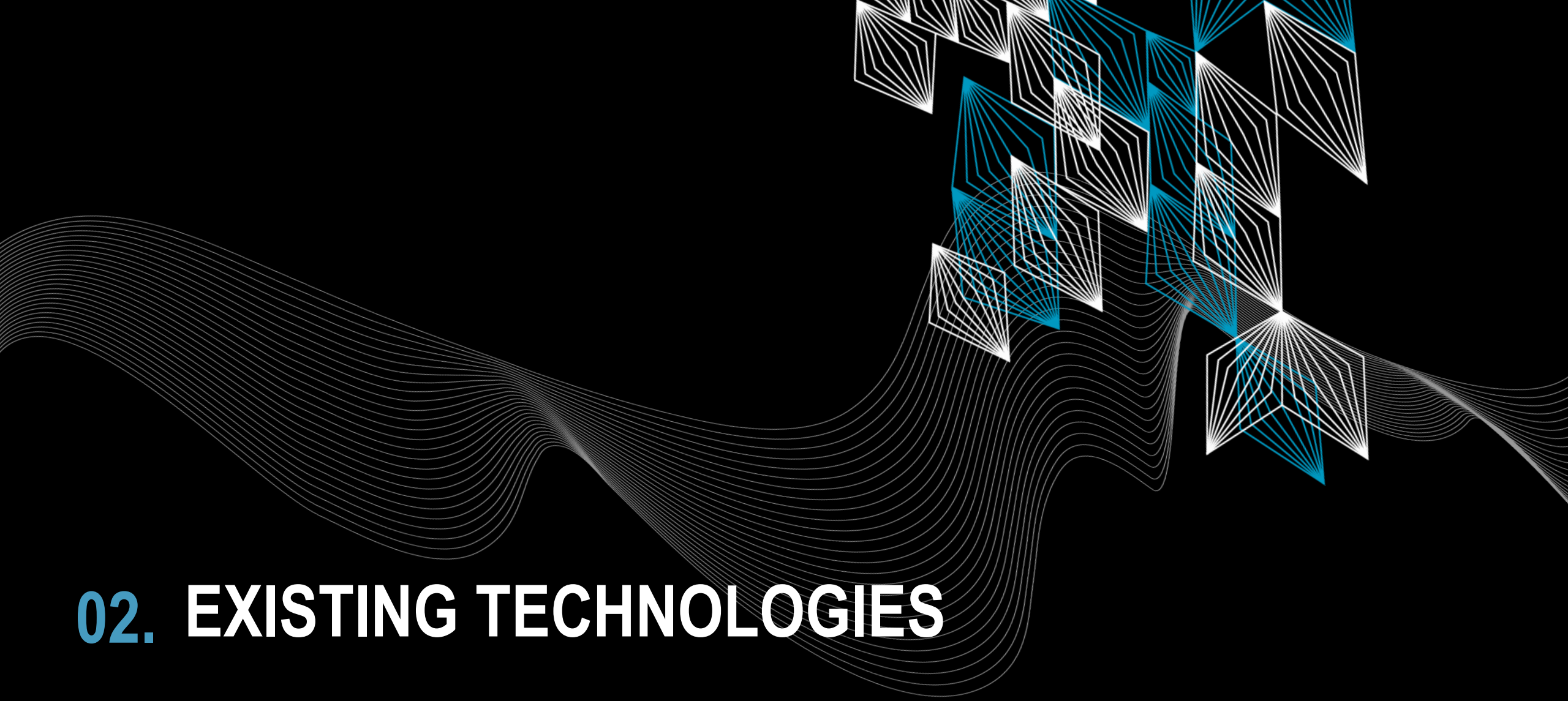
- Currently, users cannot specify trust requirements such as certified routers or routers from specific manufacturers



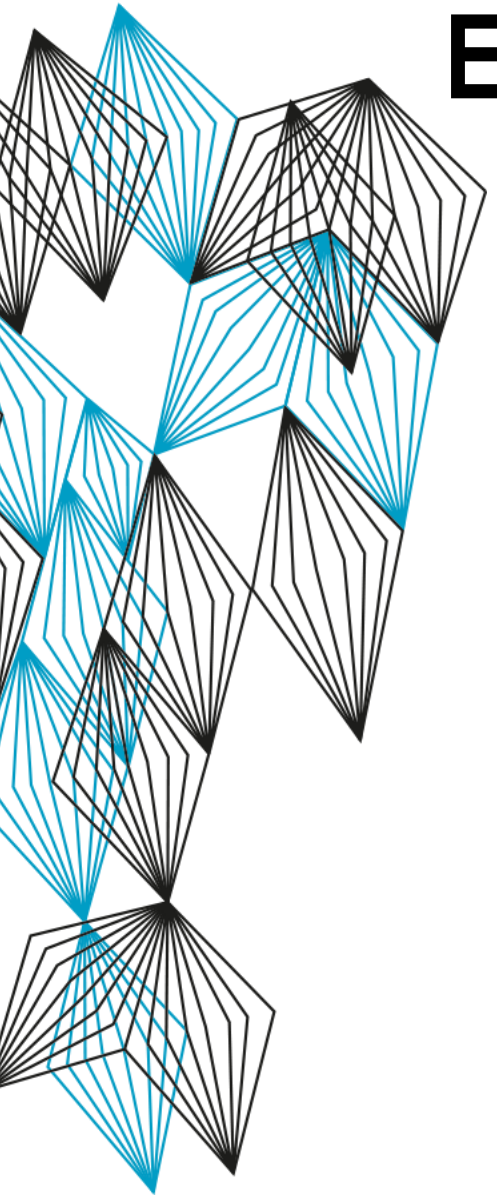
POWER GRID USE CASE

- A solution would be for the power grid operators to run their own networks, however this will eventually become unfeasible due to the decentralized nature of the energy grids

- In order to support critical infrastructures such as this power grid, the network must provide higher level of transparency, accountability and controllability to the user
    - Specifically in the multi-domain scenario

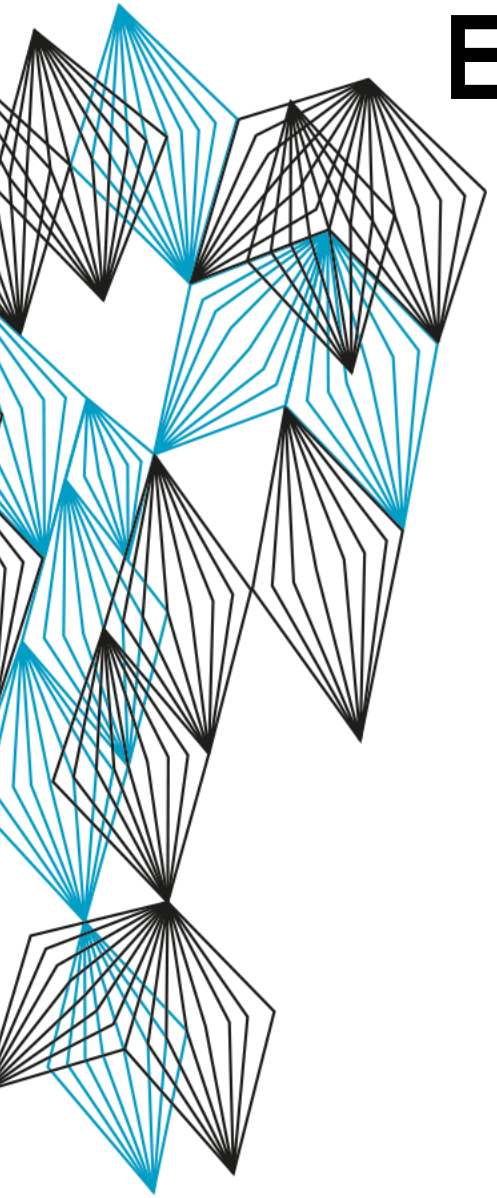


02. EXISTING TECHNOLOGIES



EXISTING TECHNOLOGIES

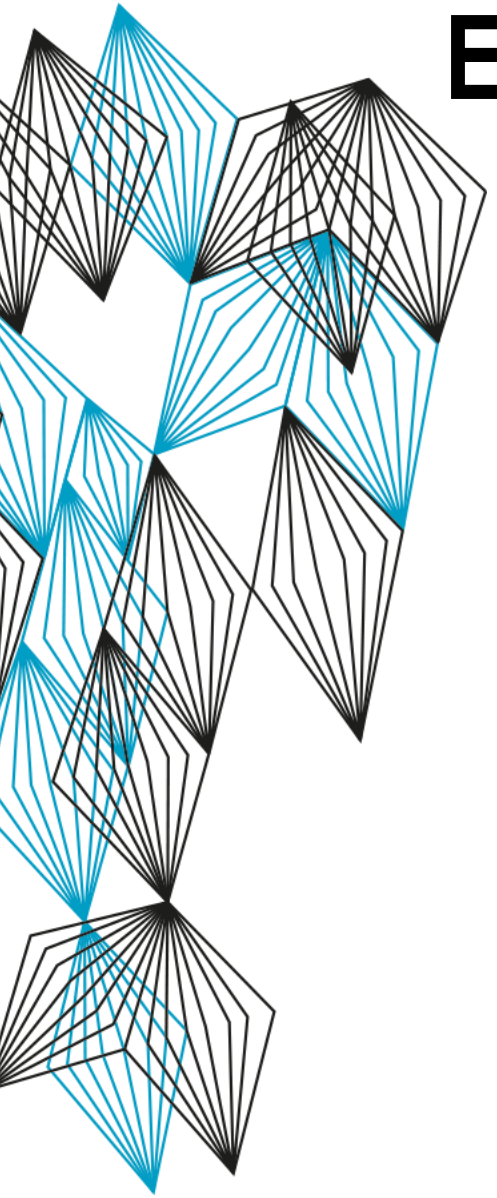
- The requirements observed while analyzing use-cases are not fulfilled by current existing, deployed and production architectures
- On the other hand, a handful of technologies partially solve the problem
- We review the literature for technologies that assess each one of our requirements
  - Transparency
  - Controllability
  - Accountability



EXISTING TECHNOLOGIES

TRANSPARENCY

- There are no solutions that provide:
  - Verifiable metadata of Inter-domain networks properties in an agnostic way
  - Provides metadata of network equipment, domains and network operations on the data path
- SCION for example, provides transparency in many ways. But not transparency about network equipment and domains.
- Programmable Data Planes (PDP), e.g. based on P4, allows fine grained state information from routers and forwarding paths
  - For our goals on transparency, PDPs appear to be the best towards it

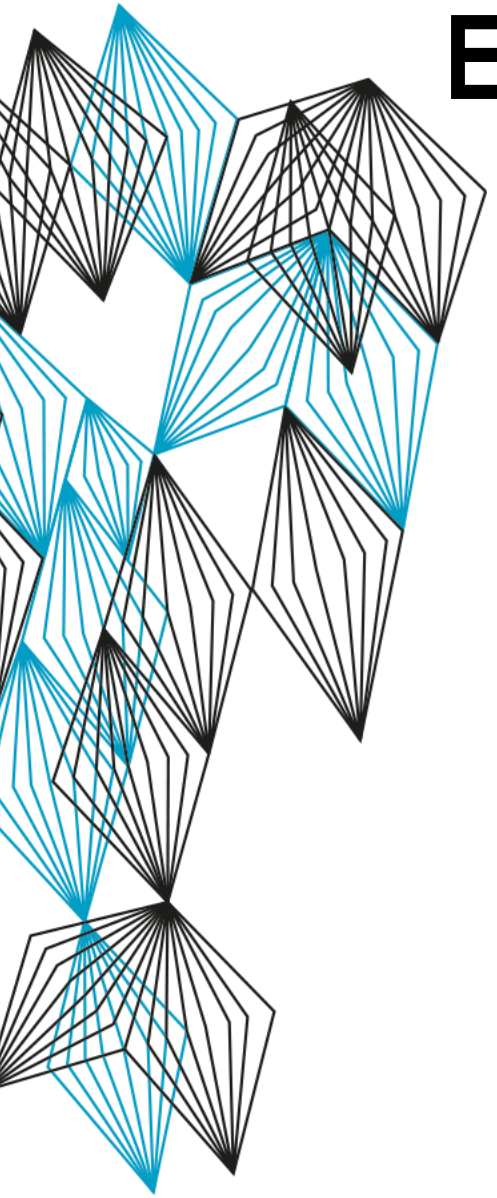


EXISTING TECHNOLOGIES

CONTROLLABILITY

- Path-Aware Networks (PANs) enables end-hosts to select the path their data will follow in the level of Autonomous Systems
  - Under the IETF, PANs are considered indispensable towards a secure Internet architecture
  - Several future Internet architectures incorporate path awareness within them (SCION, NEBULA, XIA…)
  - Unfortunately, the current Internet is completely “Path-Unaware”

- Segment Routing is one solution that allows controlling data paths on intra-domain scenarios, partially solving our problem



EXISTING TECHNOLOGIES

ACCOUNTABILITY

- The previously analyzed PANs are also accountable
  - With them, it is possible to achieve even real-time accountability, where packets are verified in a hop-by-hop basis, achieving the finest granularity for path verification
  - The current Internet is “Path-Unaware” so we must search for alternatives that work with the current protocols as well

- Tracing paths (e.g. with Netflow) makes it possible to monitor data paths and provide a posteriori feedback to the user (that is, after message exchange is done)
  - For example, we can infer a combination of segment routing and netflow for giving accountability and controllability to users (unfortunately, on single-domains only)

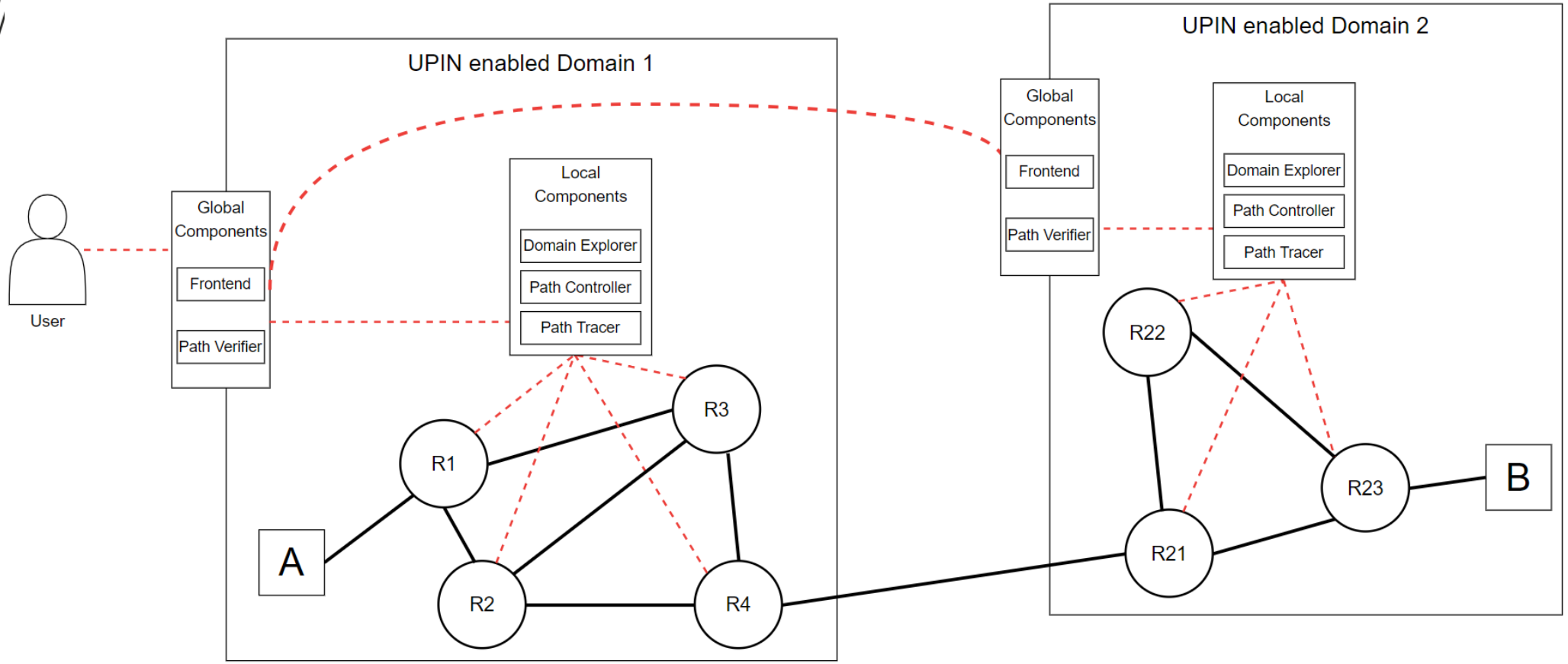
EXISTING TECHNOLOGIES

- No single solution offers a solution to all our desired properties
- Affirming our idea that a new design that combines aspects from these technologies is needed

Solution	Transparency	Accountability	Controllability
Programmable Data Planes	X	X	-
Segment Routing	-	-	X
Path-Aware Networking	-	X	X

03. UPIN SOFTWARE ARCHITECTURE

UPIN SOFTWARE ARCHITECTURE



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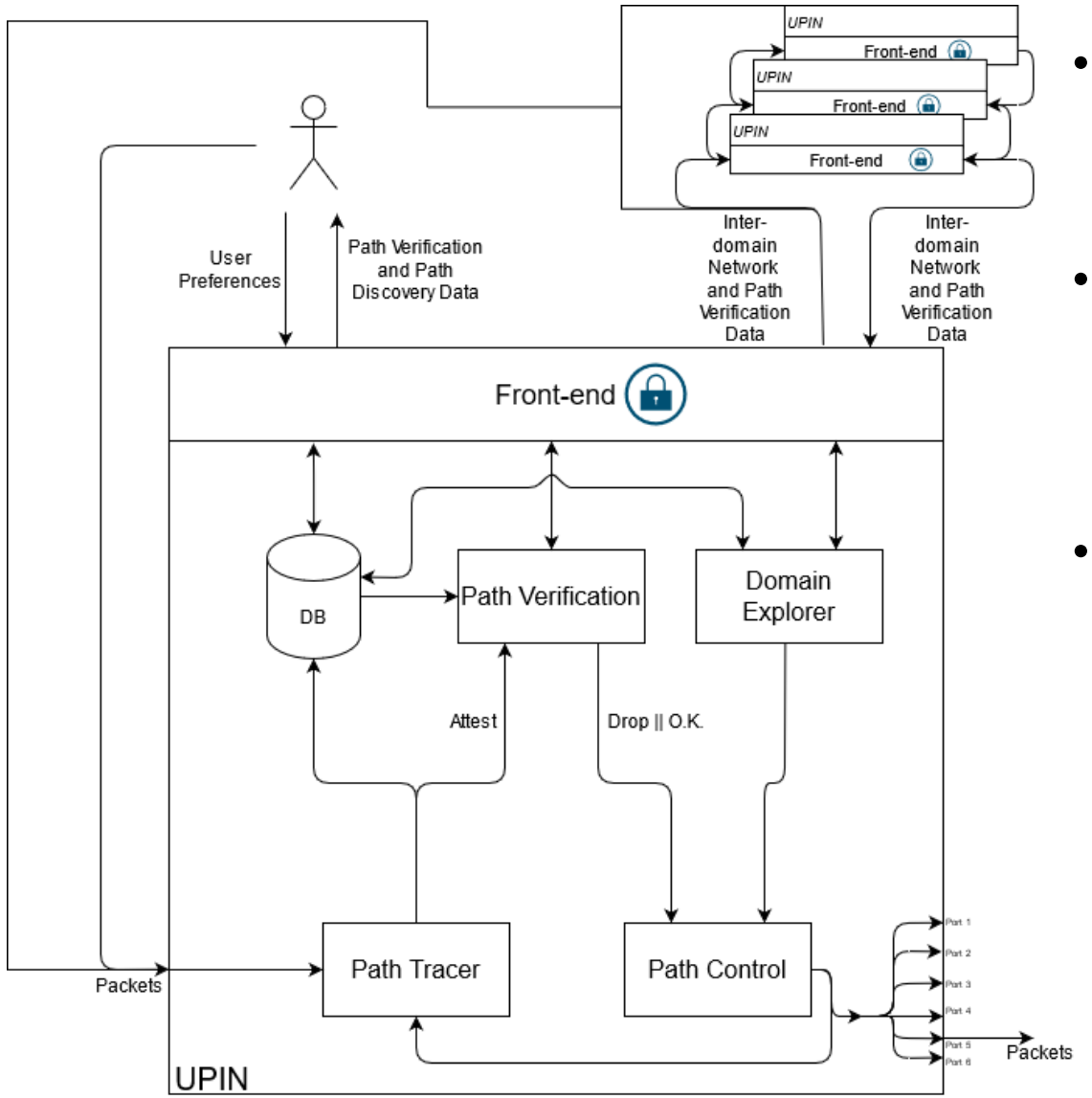
UPIN SOFTWARE ARCHITECTURE



- Initial software architecture of the UPIN prototype
- All components from our network architecture are mapped as functions in the diagram
- Current Envisioned “Threads”:
  1. Domain Exploring
  2. User Settings
  3. Path Controlling
  4. Path Verification

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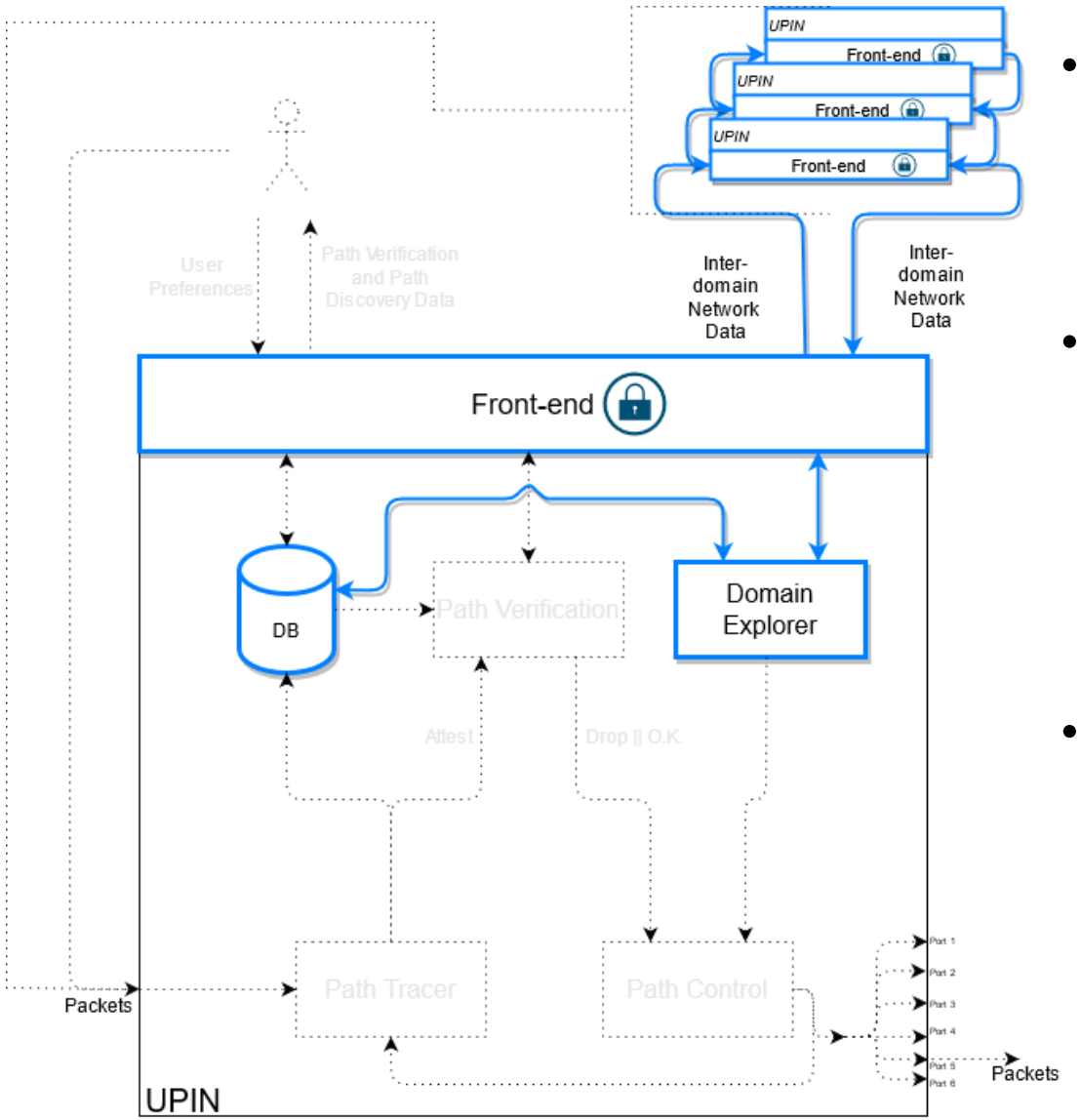
DOMAIN EXPLORING



- The UPIN prototype will constantly probe other domains for their information
- Our database will constantly be updated with data of other domains in order to keep overhead and latency to a minimum
- All information flowing through the Front-end must be encrypted

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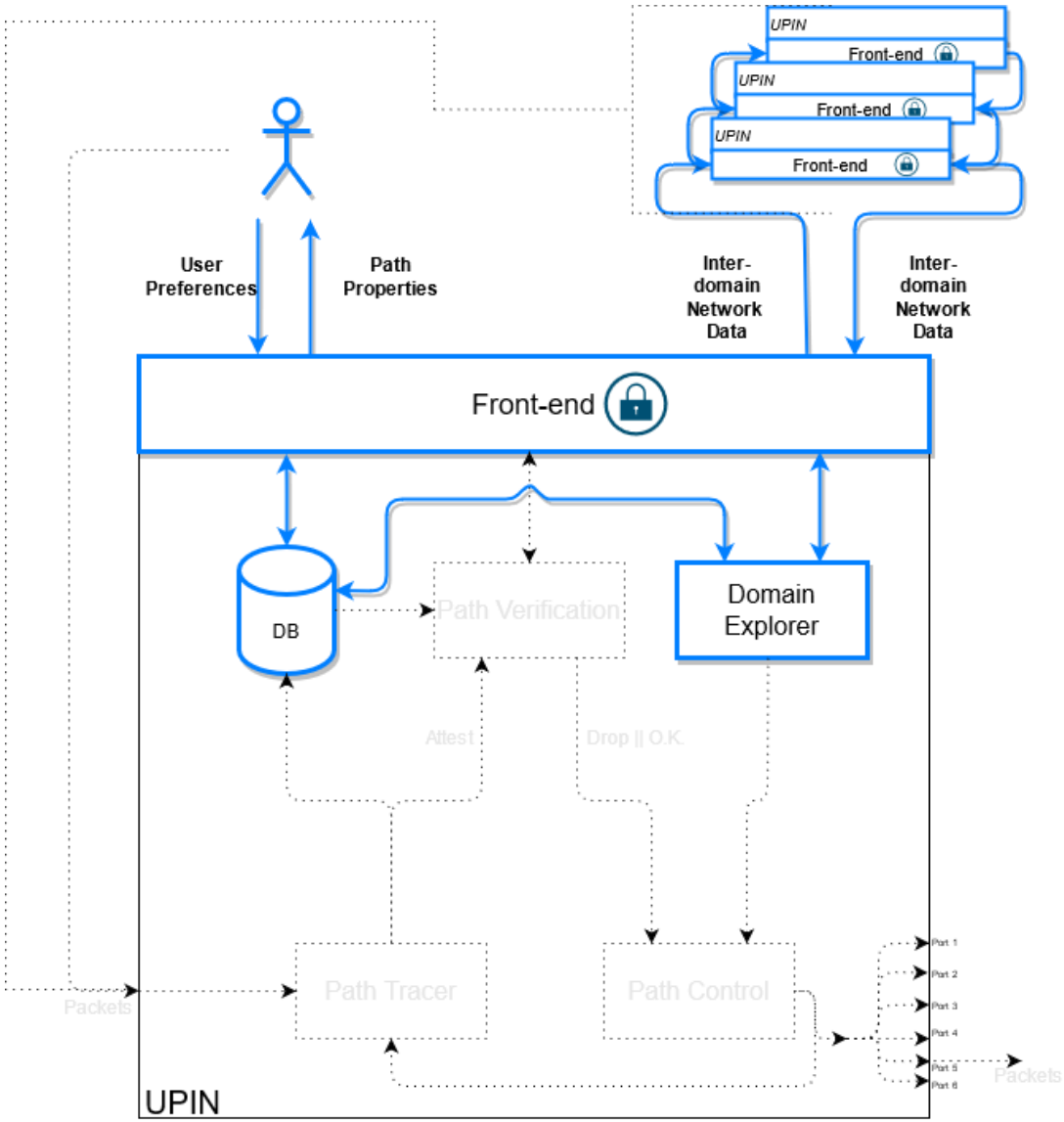
USER SETTINGS



- Users access the system through the Front-end. Existing information of users is fetched if it exists
- When setting their preferences, users add a specific destination and the system returns the available properties for that path to the user (if there is no info for that destination on the DB, the Domain Explorer will be prompted to fetch it)
- All information flowing through the Front-end must be encrypted

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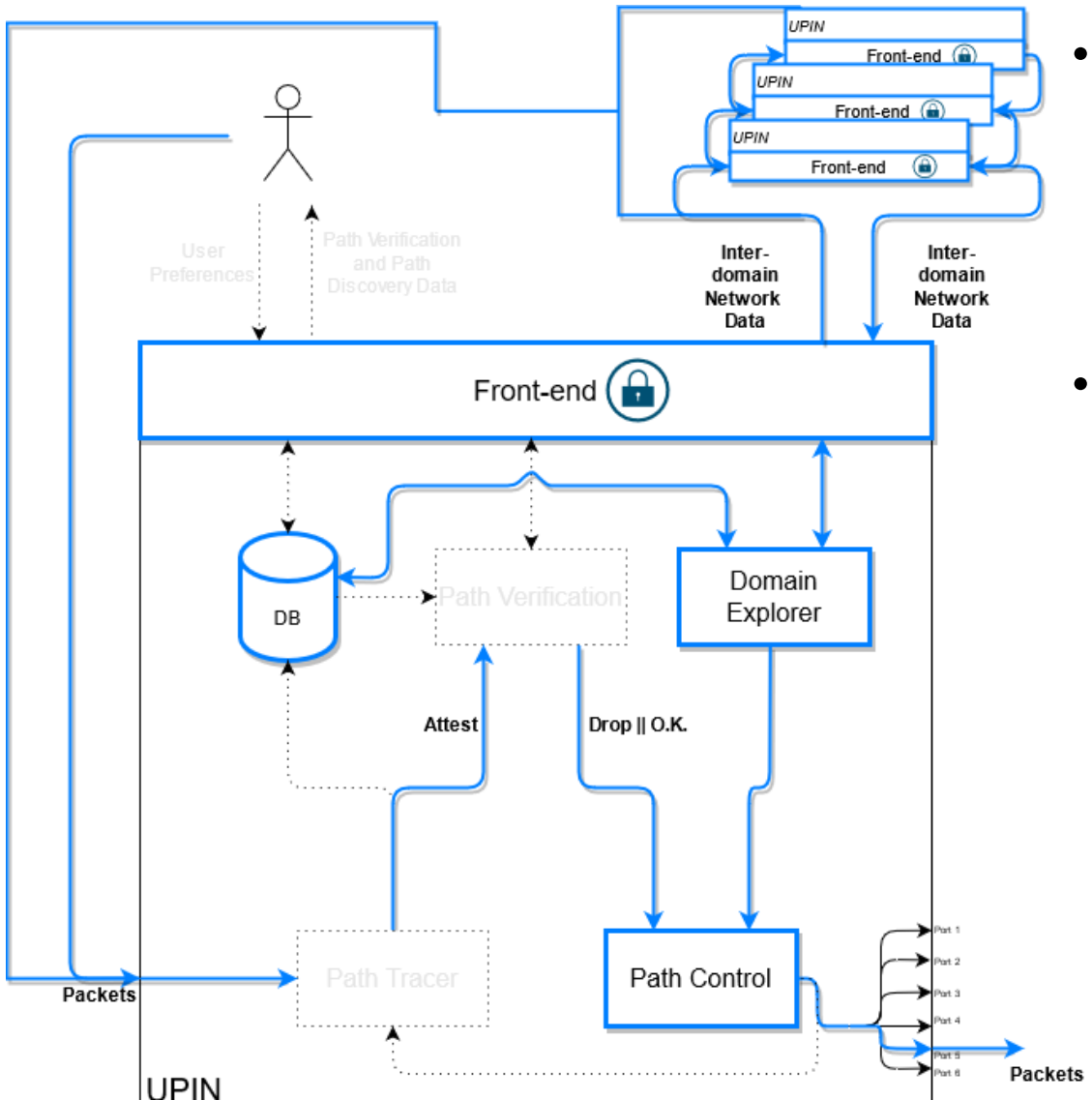
PATH CONTROLLING



- With settings in place, the system starts routing data based on preferences set or Inter-domain data received by other domains
- Upon receival of packets by the Path Control module, it forwards the packets based on data provided by the Domain Explorer and/or embedded in the packet's headers

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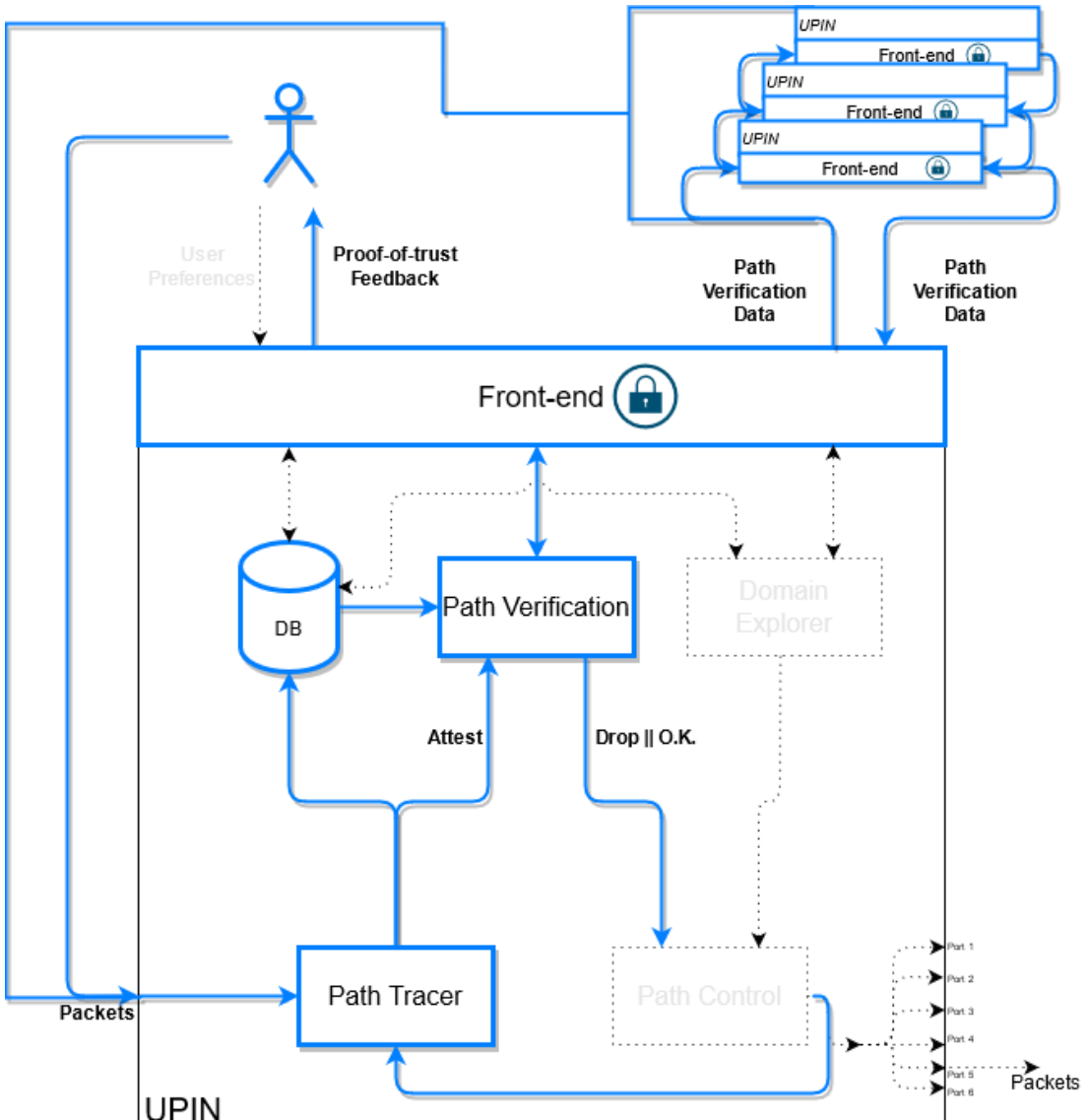
PATH VERIFICATION



- Upon receival of new packets or Path Verification Data from other domains, the software proceeds to conduct the Path Verification
- Traces are gathered in the ingress and egress of the router for verification purposes
- Traces are saved on the DB and verification is executed, forwarding a proof-of-trust to the user
- Verification can happen on real-time or a posteriori, depending of the verification method desired by the user or requested by other domains

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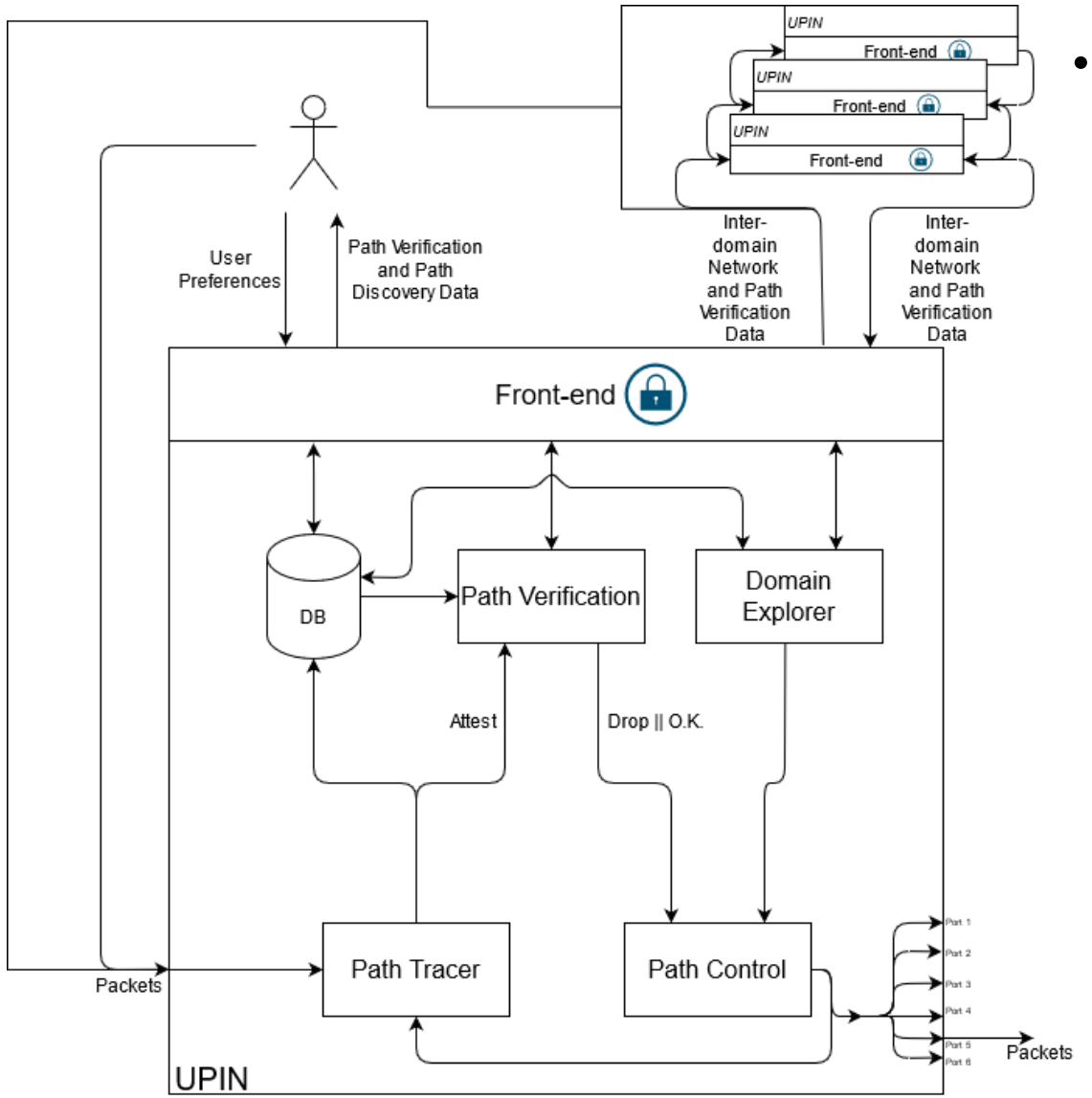
UPIN SOFTWARE ARCHITECTURE



- This is the first version of the software architecture of UPIN router that will be implemented in P4 as a deliverable for the project
  - Modifications may be necessary

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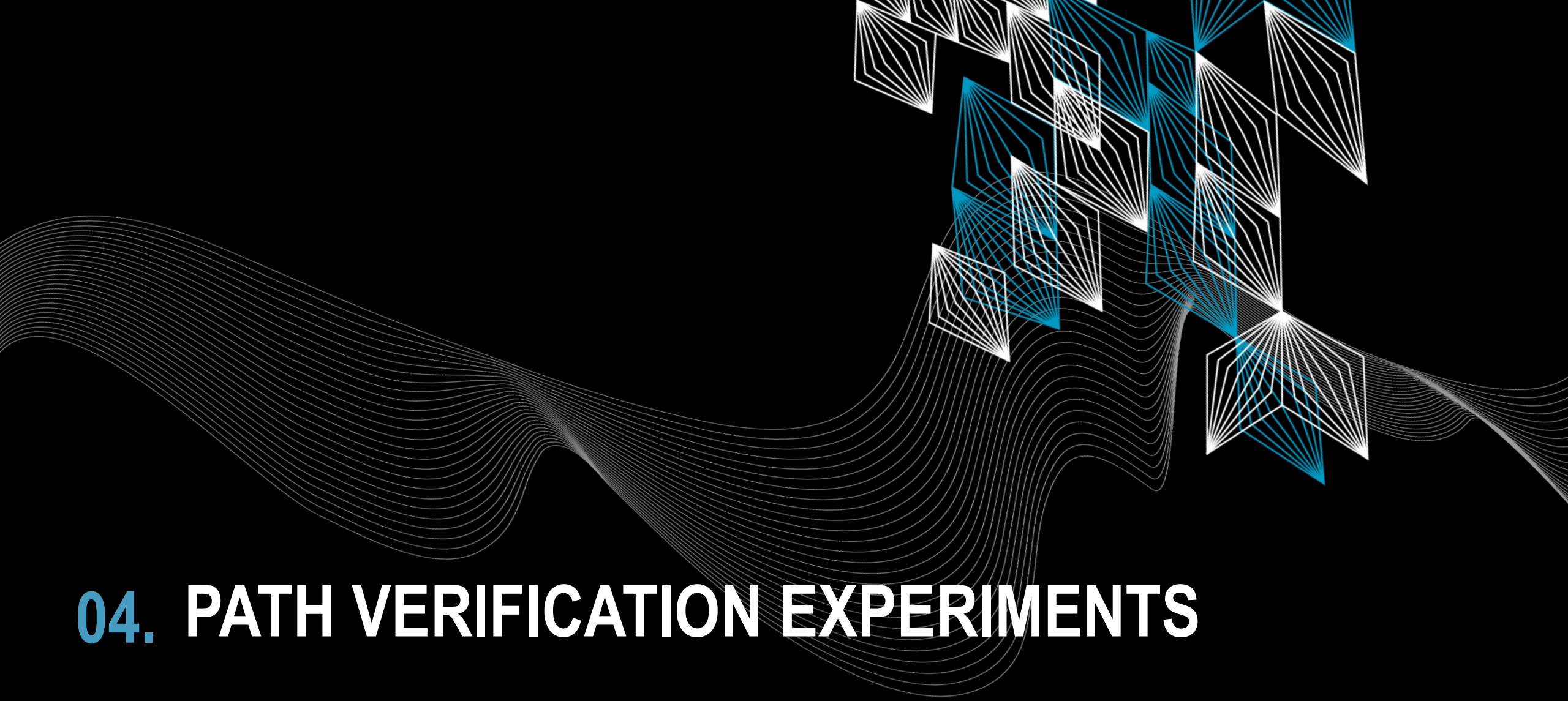

04. PATH VERIFICATION EXPERIMENTS

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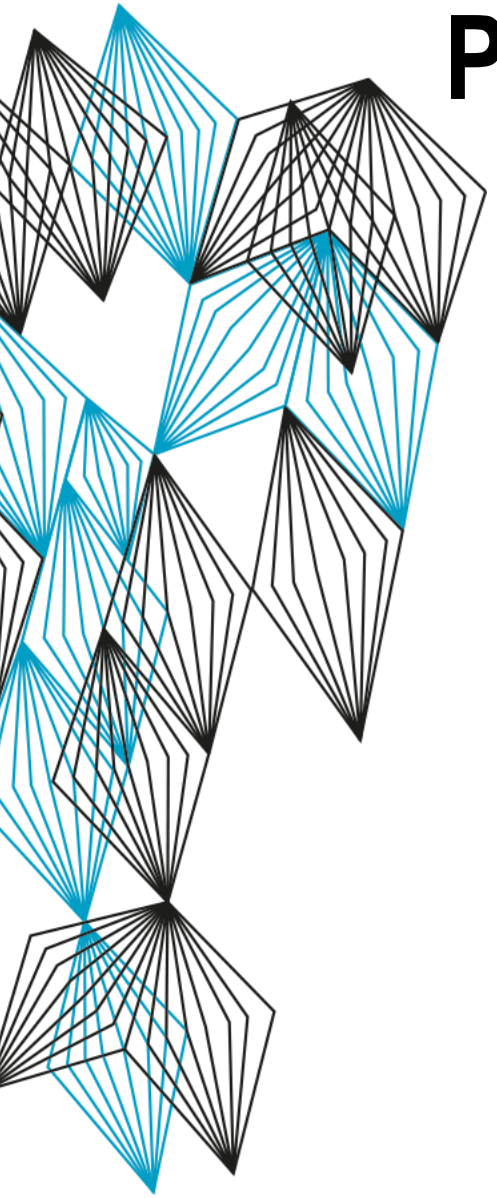
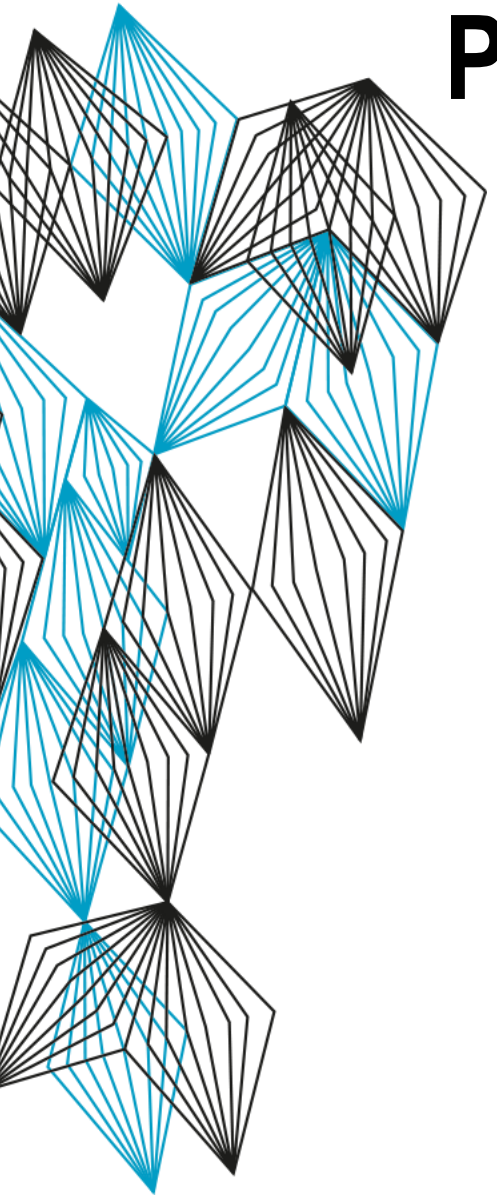
PATH VERIFICATION EXPERIMENTS



- A verification system in a simulated environment will be developed in P4 as my next UPIN task
- Fake GPS coordinates will be embedded into packets headers for verification purposes
  - Create simple verification rules for these GPS coordinates, to be embedded by the source. This will define the routers that should route the data.
- First idea is to verify the data with the use of public-key cryptography
  - Cryptography will most likely be developed with python due to easy prototyping

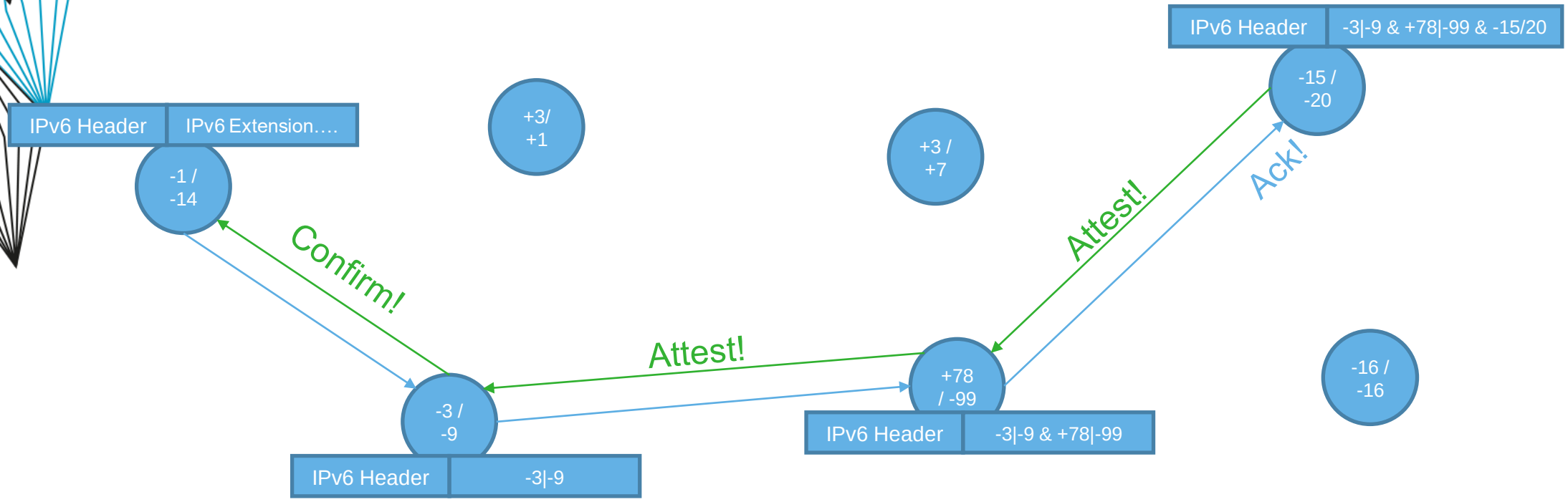
PATH VERIFICATION EXPERIMENTS



- Verify the added latency and overall overheads of adding these labels into the packets.
  - And cryptographically verifying them.

- Have the system to send data with and without probing other routers about their gps coordinates. Simulating a simple version of “Domain Explorer” component.
  - Hypothesis: Forwarding data without this will take way longer and significantly increase the latency.

PATH VERIFICATION EXPERIMENTS



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05. REQUIREMENTS AND USERS SURVEYING

REQUIREMENTS AND USERS SURVEYING

- We started initial contact with other researchers from other areas in the last months.
- Initial meetings with a researcher from the robotics team from the UT were conducted in order to gather requirements
  - Notes and observations from our meetings will be written in the form of a blog in the future
- We are looking at conducting further surveys with other industry people and researchers in order to gather more requirements for further elaborating the research