Chair of Network Architectures and Services
Department of Informatics
Technical University of Munich

Achieving Reproducible Network Environments with INSALATA

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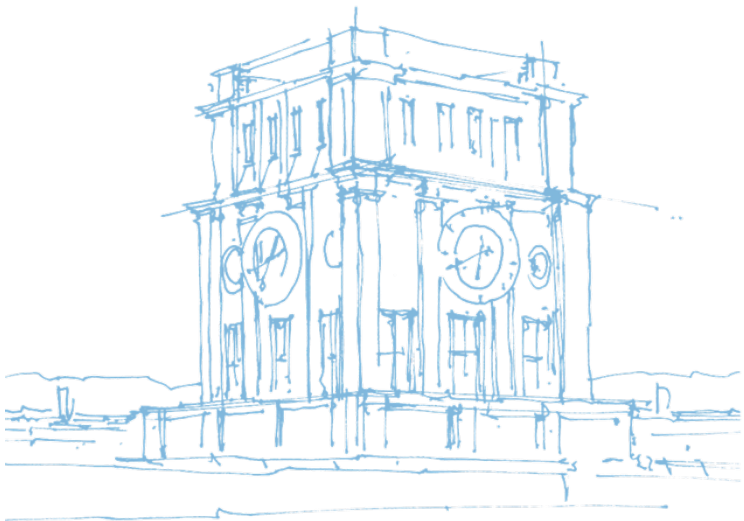

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Motivation

Why do we want reproducible network environments?

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- Requirement for reproducible experiments
  - e.g. from other testbeds

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- Requirement for reproducible experiments
  - e.g. from other testbeds
- Test changes before deployment in operational network
  - Routing
  - Software updates
  - Firewall rules
  - Configuration changes
  - ...

Our Solution: INSALATA

Manual replication:

- Error prone, time consuming
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Our Framework: IT NetworkS AnaLysis And deploymenT Application (INSALATA)

- Network information model
- Information collection component
- Infrastructure deployment component

Requirements	IF-MAP [1, 20, 21]	IDS Ontology [22]	INDL [18, 10, 8]	NML [24, 23]
R1: Network components	✓	✓	✓	✓
R2: Connections	✓	✓	✓	✓
R3: Addressing	✓	✗	✗	✗
R4: Reachability of components	✗	✗	✗	✗
R5: Network services	✓	✓	✓	✗
R6: Hardware information	✓	✗	✓	✗
R7: Extensibility of information elements	✓	✓	✓	✓
R8: History	✗	✗	✗	✓

✓ fulfilled, ✗ not fulfilled

Requirements and Related Work

Information Collection Component
Requirements and Related Work

Requirements	IO-Framework [4, 12]	cNIS [9]	MonALISA [6, 5]	PerfSONAR [19]	OpenVAS[16]	Nmap [13, 14]
R1: Configurability	✗	✓	✓	✓	✓	✓
R2: Collection of required topoloy information	✓	✗	✓	✗	✗	✗
R3: Extensible modules	✓	✓	✓	✓	✓	✓
R4: Periodical information collection	✗	✓	✓	✓	✓	✗
R5: Adaptable intervals	✗	✗	✗	✓	✓	✗
R6: Continuous monitoring	✗	✓	✗	✗	✗	✗
R7: Multiple environments	✗	✗	✓	✓	✓	✗
R8: Extensible export	✗	✓	✗	✗	✗	✗

✓ fulfilled, ✗ not fulfilled

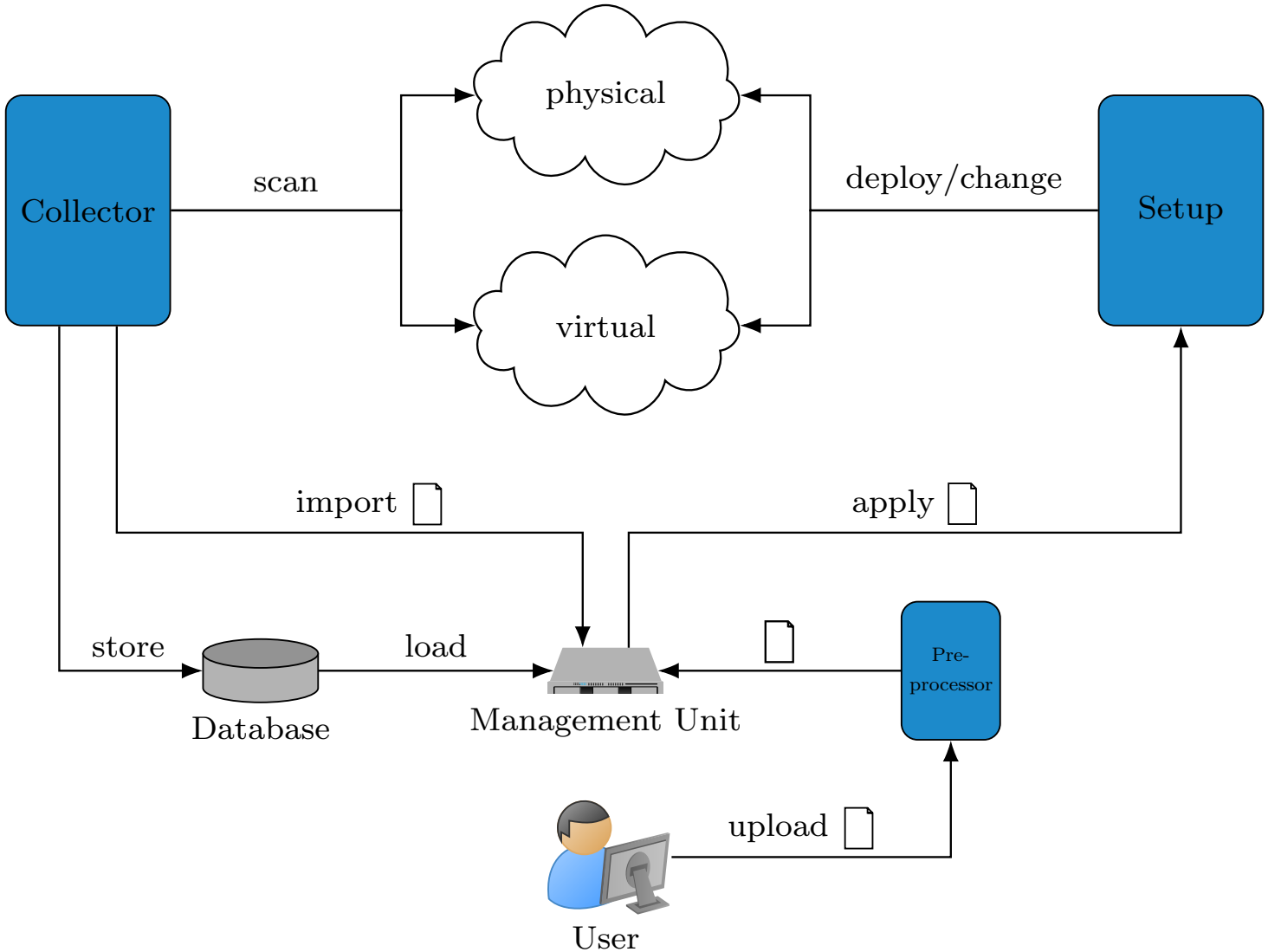
Requirements and Related Work

Infrastructure Deployment Component
Requirements and Related Work

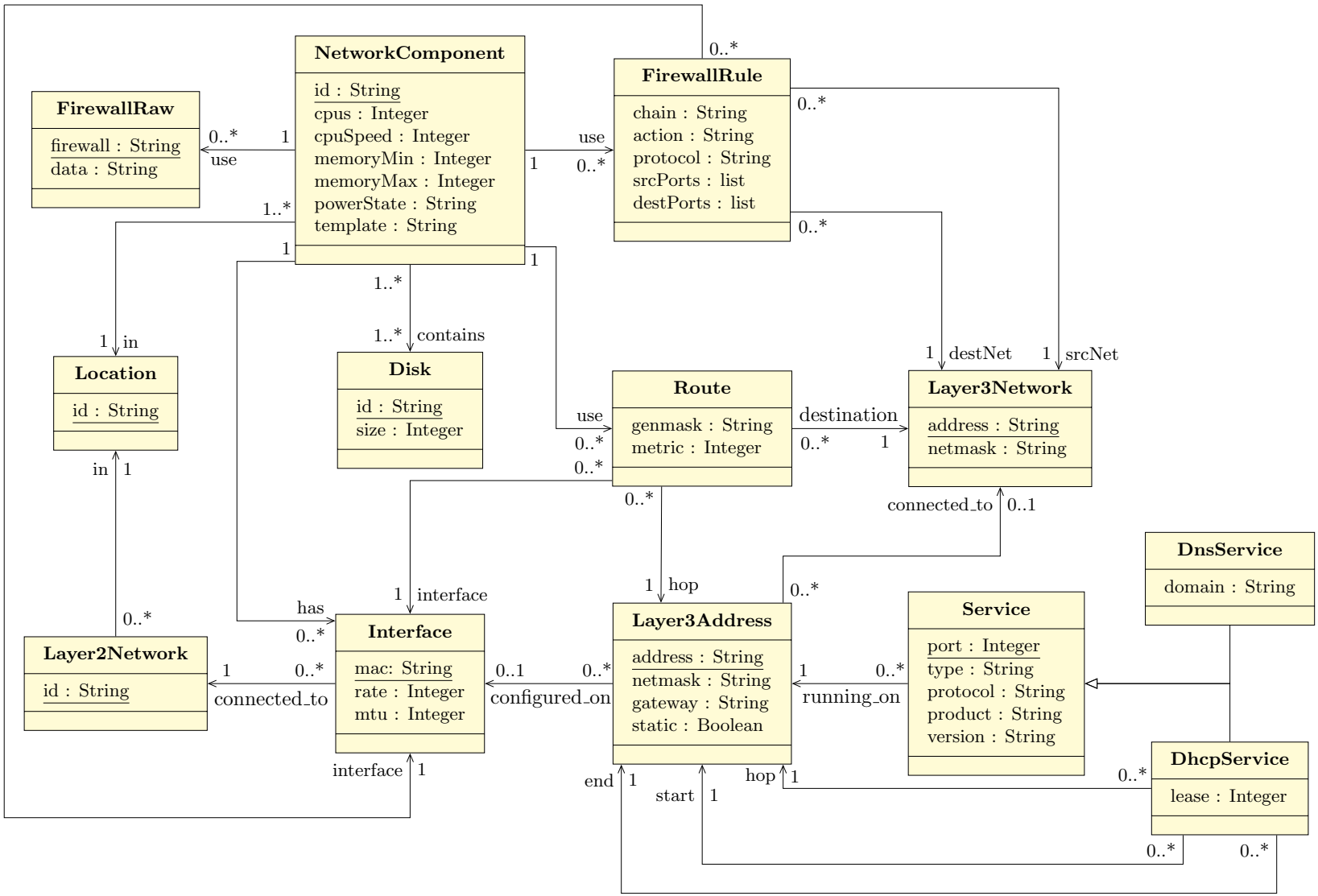
Requirements	LaasNetExp [17]	vBET [11]	Baltikum Testbed	NEPTUNE [3]	Algorizmi [2]	Emulab[25]
R1: Basic network components	✗	✓	✗	✗	✗	✓
R2: Description language for configuration	?	✓	✓	✓	✓	✓
R3: Virtual and physical components	✗	✗	✓	✗	✗	✓
R4: Software independent design	?	?	✗	✓	✗	✗
R5: Public availability	✗	✗	✓	✓	✓	✓
R6: Separated and persistent components	✓	✗	✓	✓	✓	✓
R7: Multiple users per testbed	✓	✗	✗	✗	✓	✓
R8: Common usage of central components	✓	✓	✗	✓	✗	✗
R9: Incremental Changes	✗	✗	✗	✗	✗	✗

✓ fulfilled, ✗ not fulfilled, **?** insufficient information

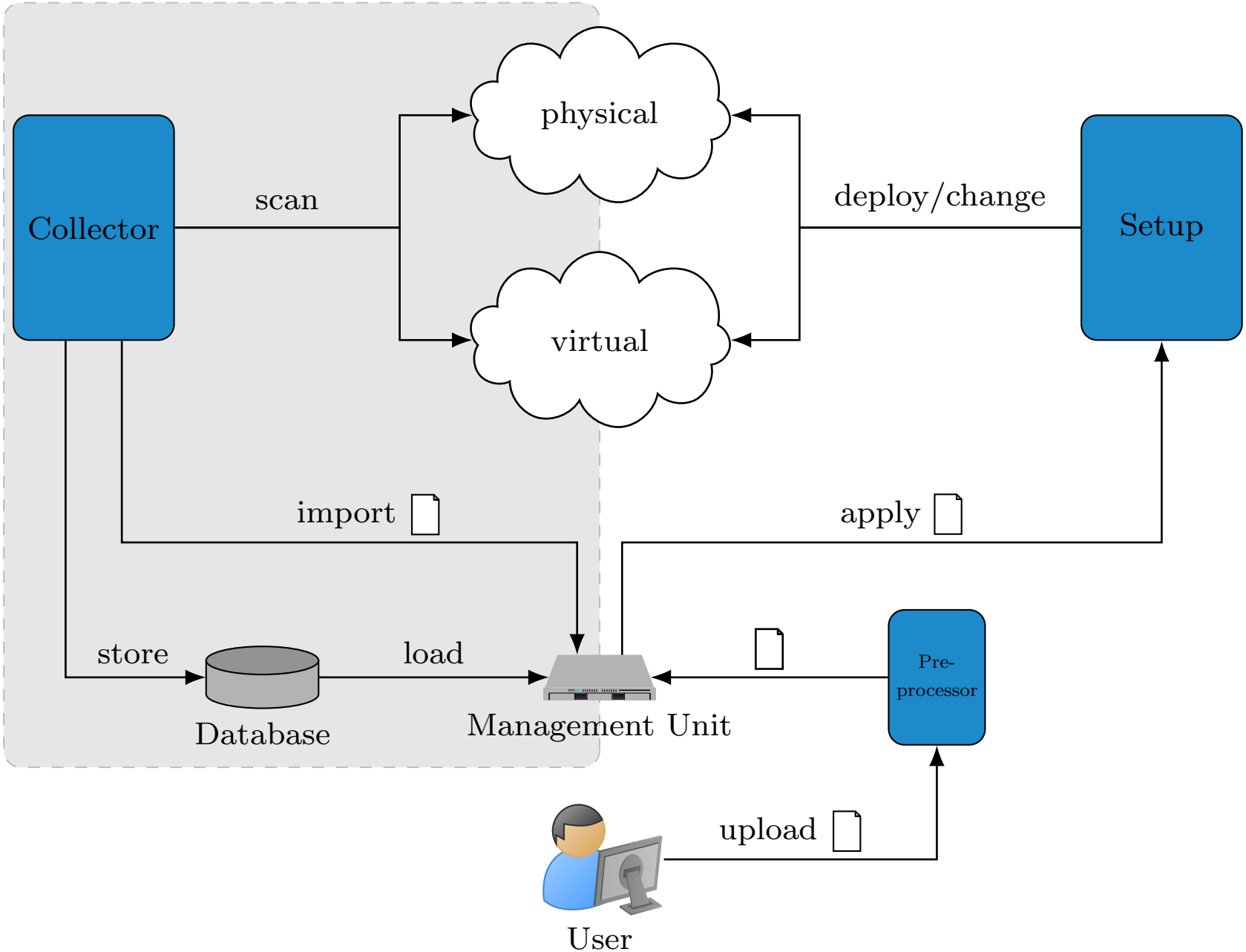
Architecture: Overview



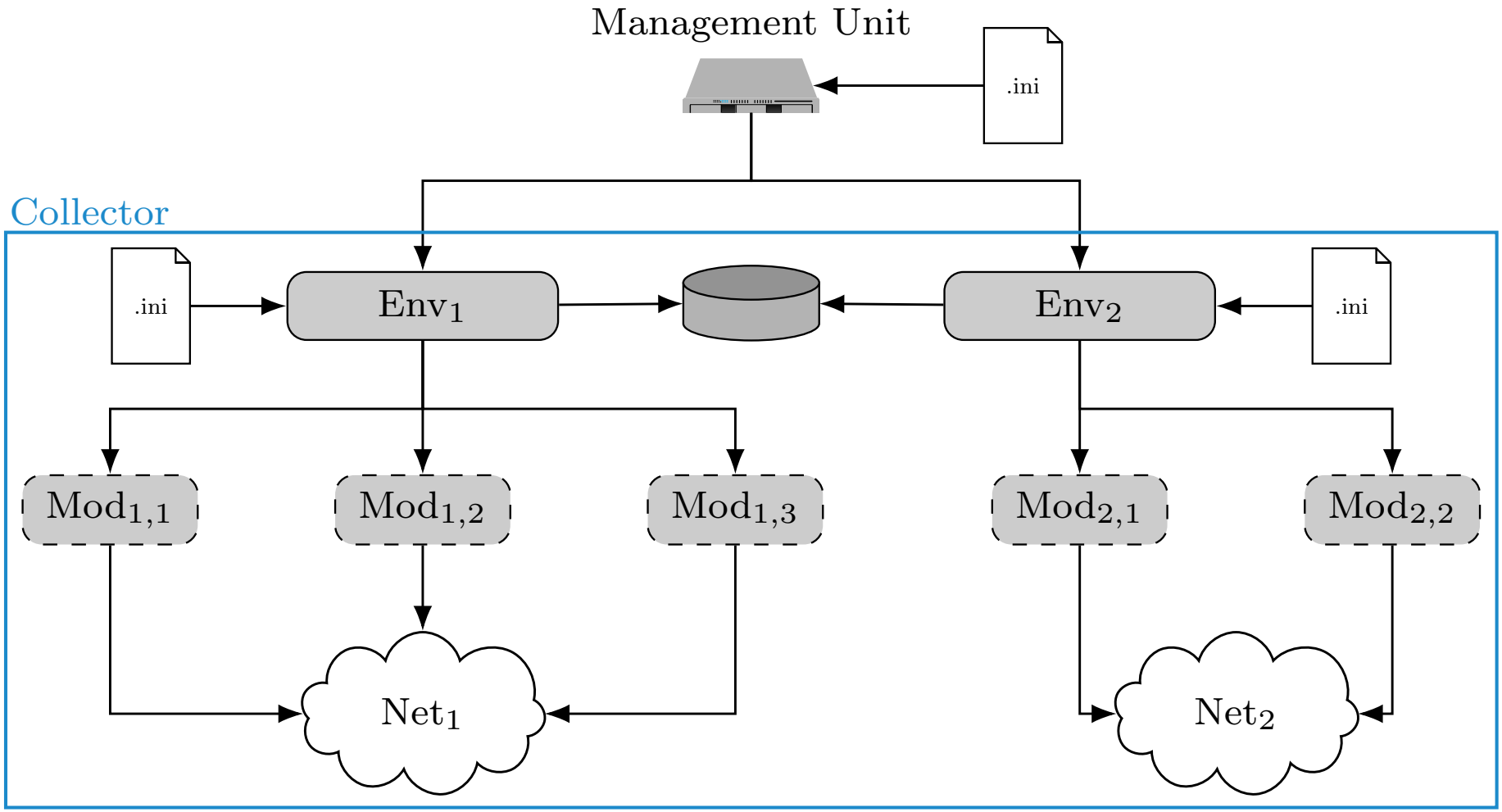
Architecture: Information Model



Architecture: Information Collection Component



Architecture: Information Collection Component

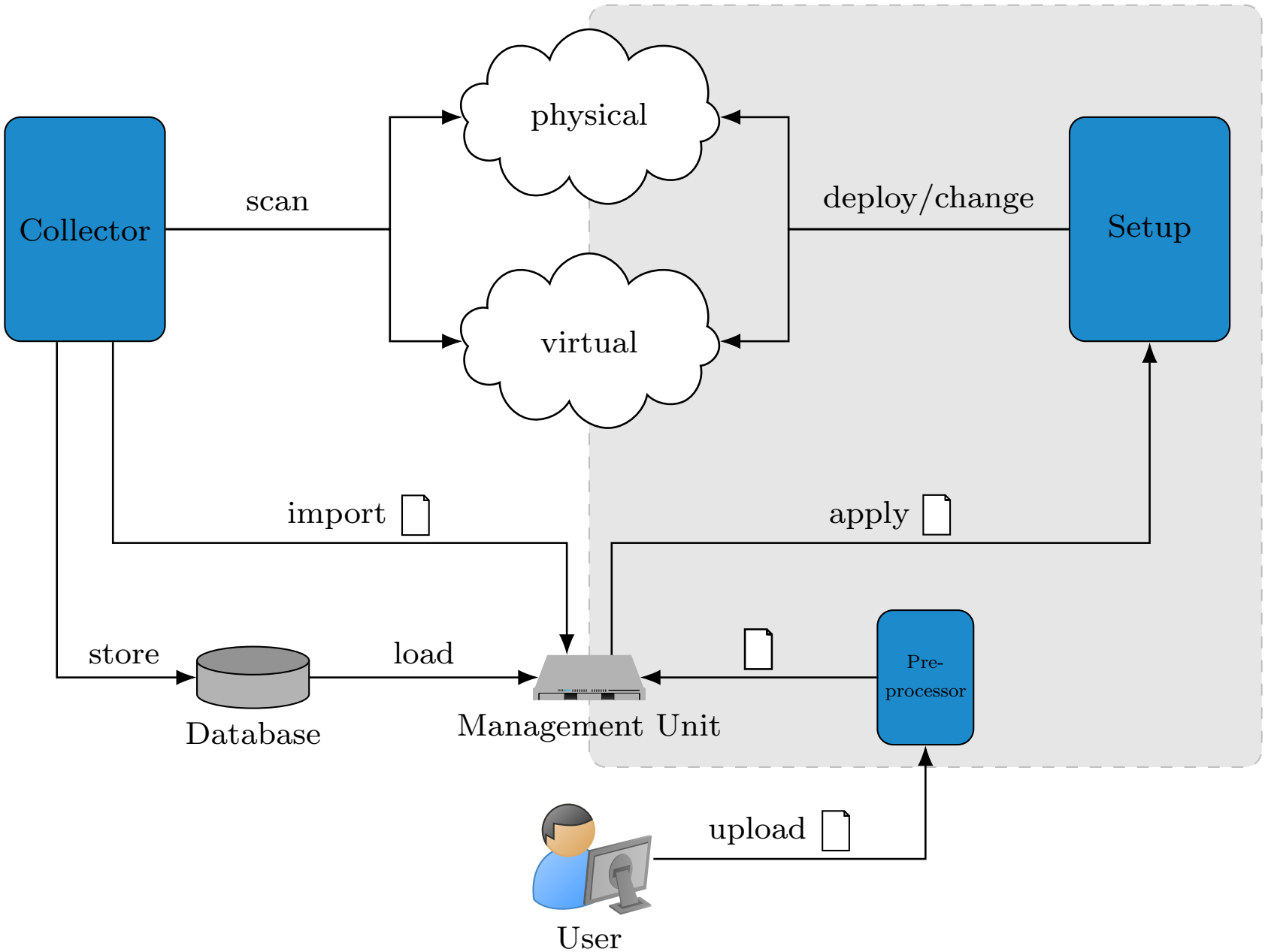


Architecture: Information Collection Component

Approaches for Information Collection

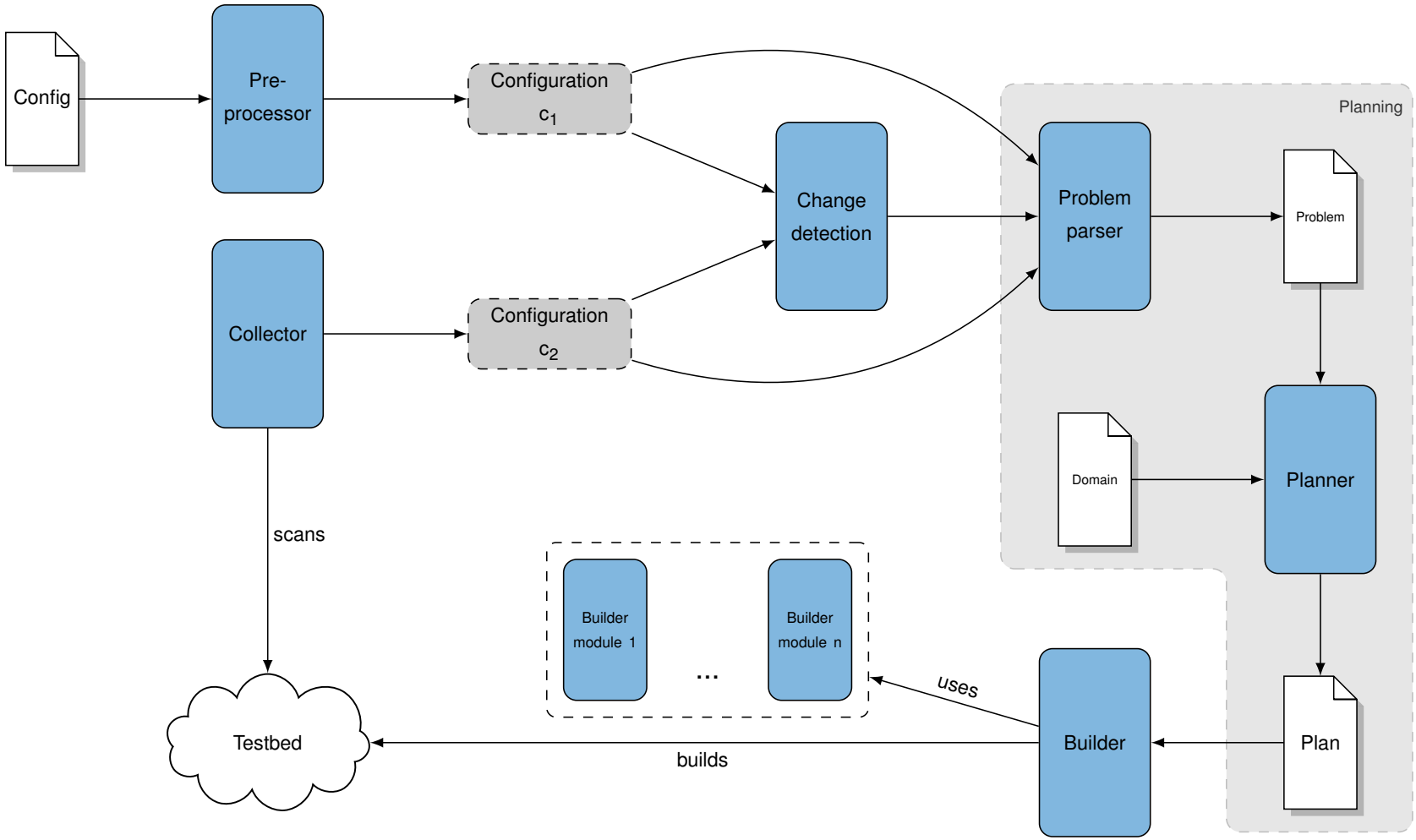
	Manual (xml)	Passive scans (tcpdump)	Active scans (NMAP)	protocol based (SNMP)	Direct access (ssh)	Client software (Zabbix)
Network traffic overhead	o	o	++	+	+	+
Client software	o	o	o	+	+	++
Direct access	o	+	o	o	++	+
Reliability	+	++	+	++	++	++
Topicality	o	o	+	+	+	++
Information variety	o	+	+	+	++	++
Information updatability	+	o	++	++	++	++

Architecture: Infrastructure Deployment Tool



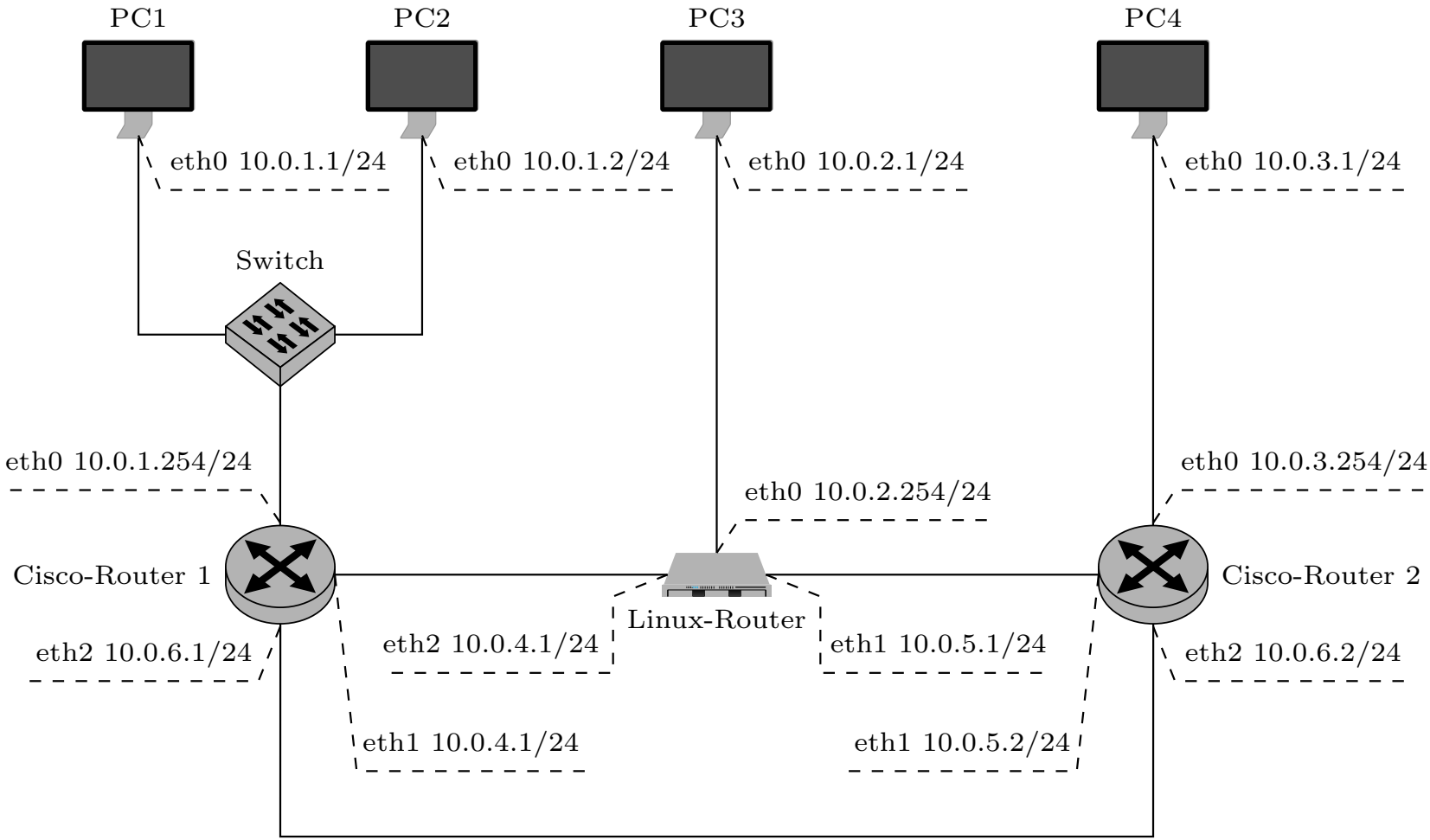
Architecture: Infrastructure Deployment Tool

Deployment Process



Case Study: iLab

Physical setup



Case Study: iLab

Deployment Phase

- Execution plan computed in <1 second
  - 92 steps
  - Contains: setup of virtual machines, networks, interfaces, routes,...
- Setup in our virtual testbed took ~42 minutes
  - Our builder modules utilize the XEN xapi toolstack
  - Most of the time required to clone the virtual machines and hard disk images
- Validation of setup in the testbed using the ping and traceroute tools

Conclusion and Future Work

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- Contribution:
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  - Multiple collector/builder implementations
  - Case studie as prove of applicability
- Future Work:
  - Implement additional collector/builder modules
  - Parallelize the deployment process
  - Include experiment execution

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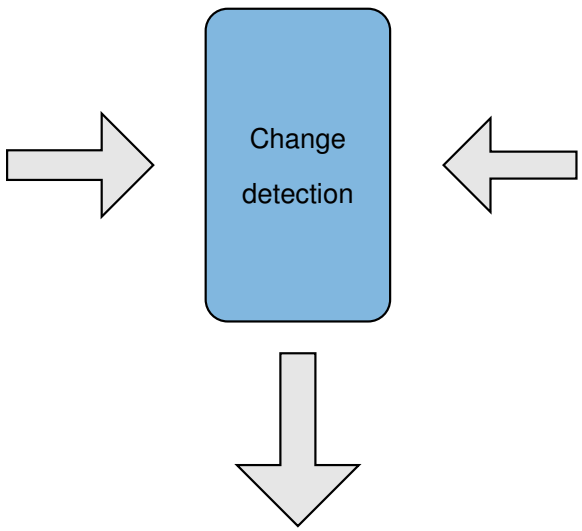
Change Detection

networks:
- ▶ net-1
- ▶ net-2

hosts:
- ▶ router-1
  - • interfaces:
    - – eth0: 10.10.1.254/24
    - – eth1: 10.10.2.1/24
- ▶ host-1
  - • interfaces:
    - – eth0: 10.10.1.1/24



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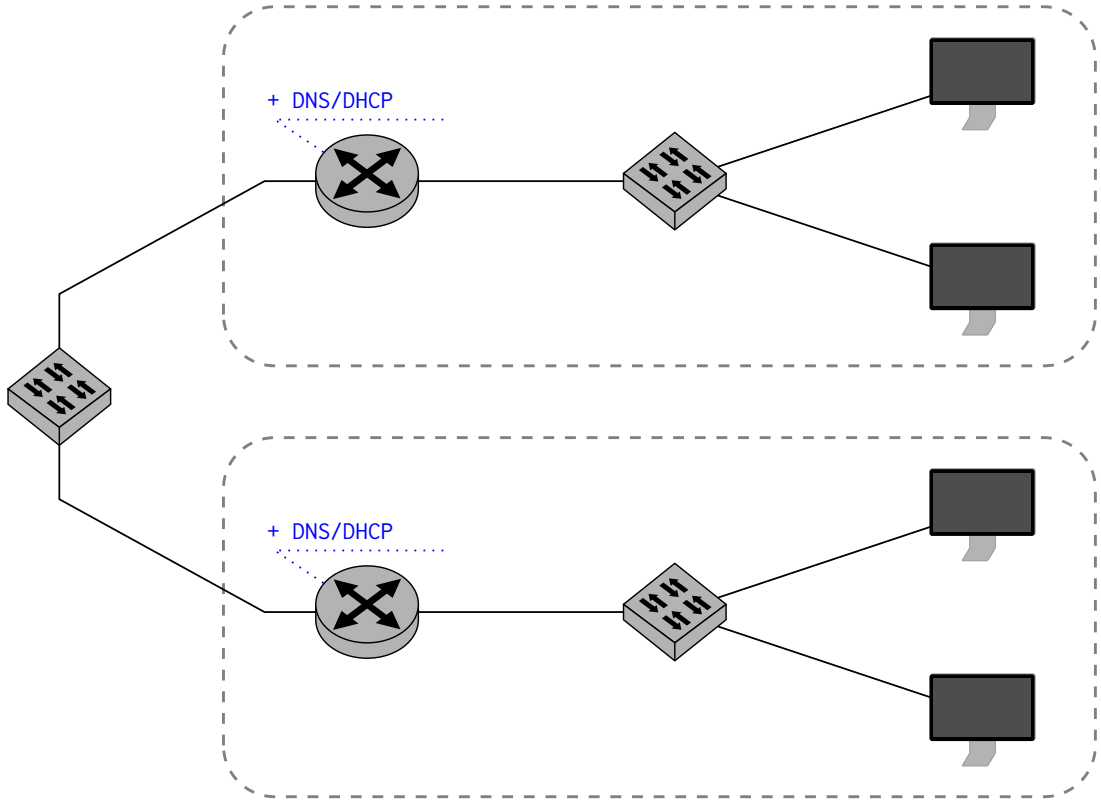
  - • interfaces:
    - – eth0: 10.10.1.1/24
- ▶ host-2
  - • interfaces:
    - – eth0: 10.10.2.1/24

The change detection marks `router-1.eth1.ip` as changed and `host-2` as new.

Planning

- Based on the input, the planner creates a deployment plan
- Currently the Planning Domain Definition Language (PDDL [15, 7]) is used
  - Domain description: describes the problem domain, static
    - Describes object types, predicates, actions
    - Actions apply to objects, have preconditions and have an effect
    - Provided with INSALATA for our information model
  - Problem description: describes the instance of the domain
    - Depends on current/desired state
- Output is given to the Builder which chooses fitting builder modules to realize the deployment

Planning Example



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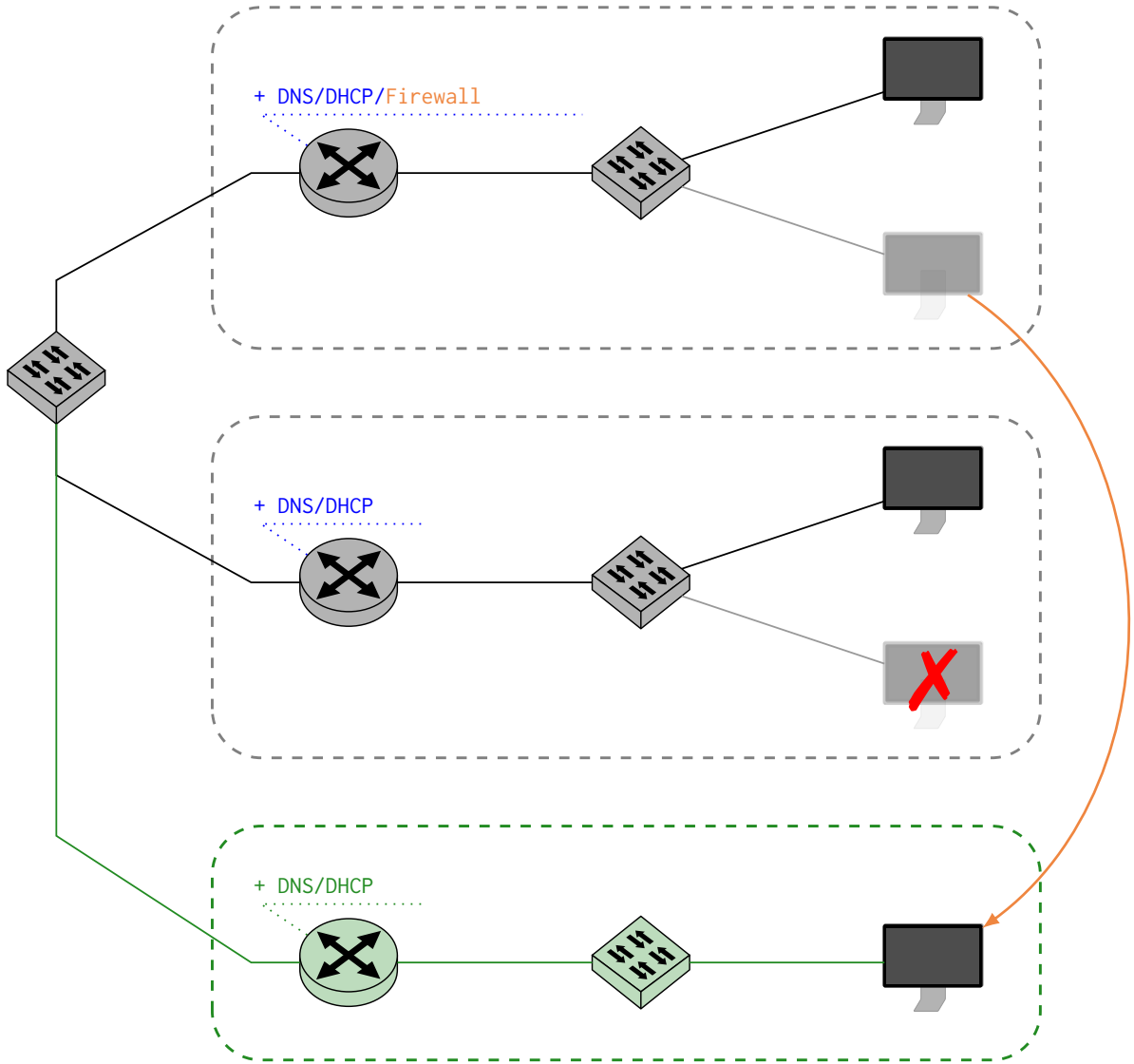

Planning example

new

- router-3

changed

- router-1.firewall
- router-1.routing
- router-2.routing
- host-3.eth0

removed

- host-4
- host-4-hdd

1. (createhost router-3)
2. (configurefirewall router-1)
3. (configurerouting router-1)
4. (configurerouting router-2)
5. (createnetwork net-3)
6. (shutdown host-4)
7. (removehost host-4)
8. (removedisk host-4-hdd host-4)
9. (createinterface router-3.eth0)
10. (createinterface router-3.eth1)
11. (bootunnamed router-3)
12. (configureinterface router-3.eth0)
13. (configureinterface router-3.eth1)
14. (configurerouting router-3)
15. (name router-3)
16. (rebootandnamed router-3)
17. (shutdown host-3)
18. (configurenetwork host-3.eth0)
19. (boot host-3)
20. (configuredhcp 172.16.246.1:67_udp_dhcp)
21. (configuredns 172.16.246.1:53_udp_dns)

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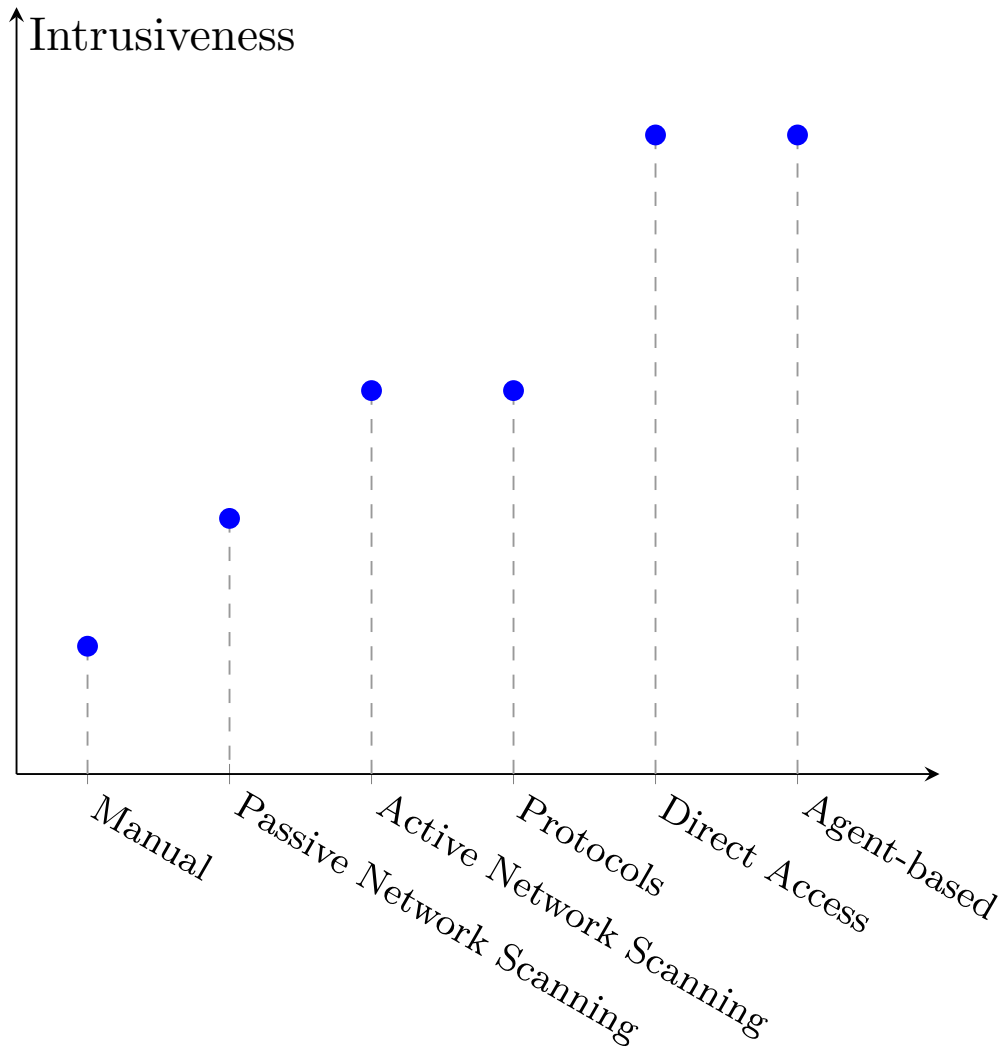
Intrusiveness of Information Collection



Quality of Information Depending on Collection Method