mPlane Architecture and Protocol

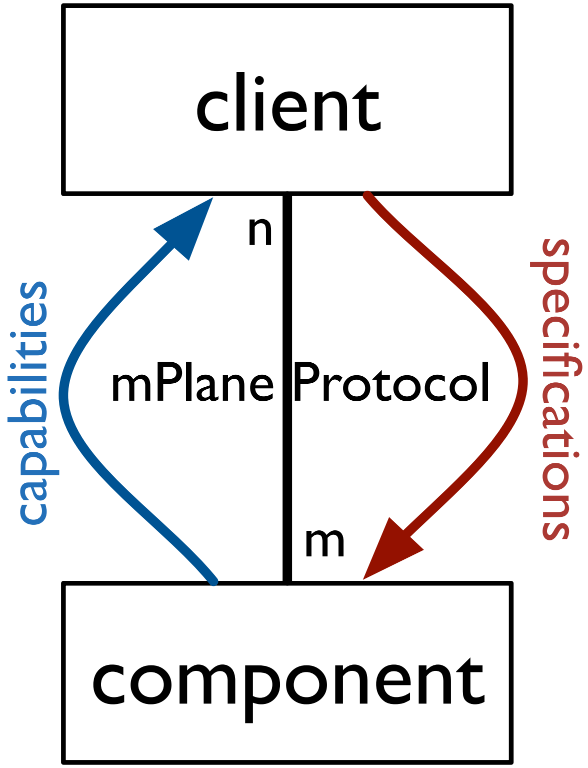
Brian Trammell, Architecture (WP1) lead
ETH Zürich

mPlane final workshop
30 November 2015, Heidelberg

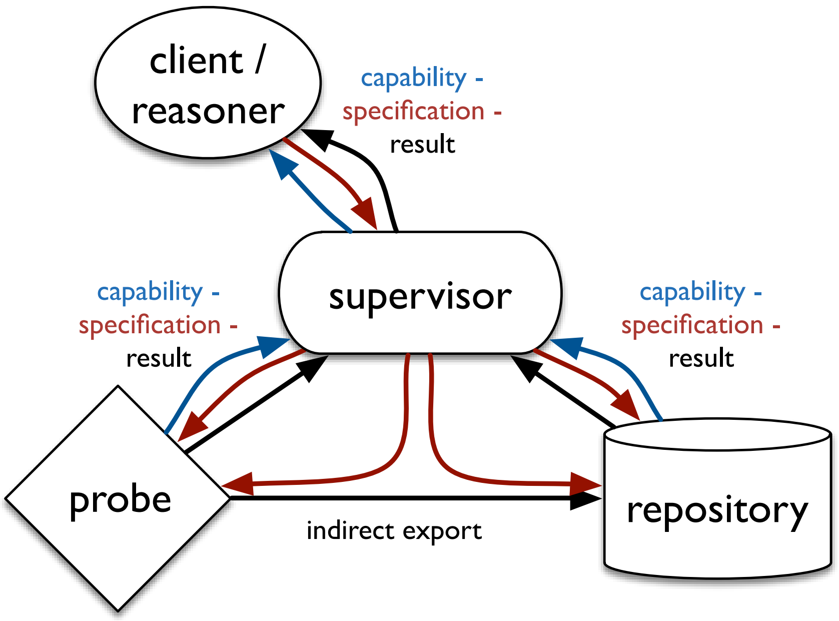
mPlane architecture

in one slide

- **Components** make measurements available to **clients** via the mPlane protocol.
  - Components can be **probes**, which measure, or **repositories**, which store and analyze.
- These measurements are *completely* defined in terms of **capabilities** advertised by the components.
- Clients send **specifications** to invoke these capabilities.
- Specifications can lead to **results**, or to components sending bulk data to others via **indirect export**.



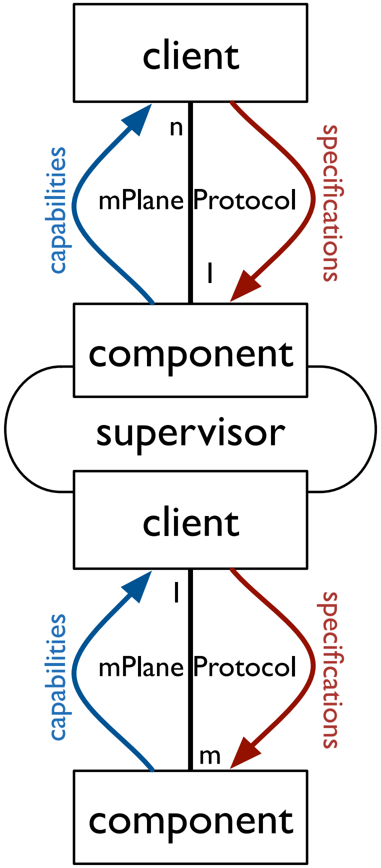
Probes, Repositories, and Reasoners



- **Probes** are components that can measure something now.
- **Repositories** are components that can answer queries about the past.
- **Reasoners** are clients with learning component for (semi-)automation of measurement workflows.

Coordination and Federation

- A **supervisor** mediates between clients and components:
  - ❑ Measurement aggregation
  - ❑ Access control centralization
  - ❑ Interdomain federation
- *Not* a measurement controller in the traditional sense due to delegation of responsibility to components.
- Requires *application-specific logic* for control distribution and result collection



Architectural Principles

- **Schema-centric measurement definition**: a measurement is completely described by the parameters it takes and the columns in the results it produces.

- **Weak imperativeness**: capabilities aren't guarantees, normal exceptions discovered in later analysis, state and responsibility dynamically distributed throughout an infrastructure.

- Component management left out of scope
  - assume components too heterogeneous anyway.

Schema-centric measurement definition

- Traditional RPC:

```
ping -c 3 -w 5 10.2.3.4
ping(count, period, dest) => [int]
```

  - Need to register entry points, argument names.
  - “Can I compare `ping()` to `webping()` to `nmap_christmas_tree_warning_very_beta()`?”

- Schema-centric:

```
measure(param(singleton_measurement_count,
              period,
              destination_ip4);
        result(delay_oneway_icmp))
```

- Requires rigorous control over the set of column names, but allows more or less infinite combination (cf. www.iana.org/assignments/ipfix)

mPlane

SEVENTH FRAMEWORK PROGRAMME

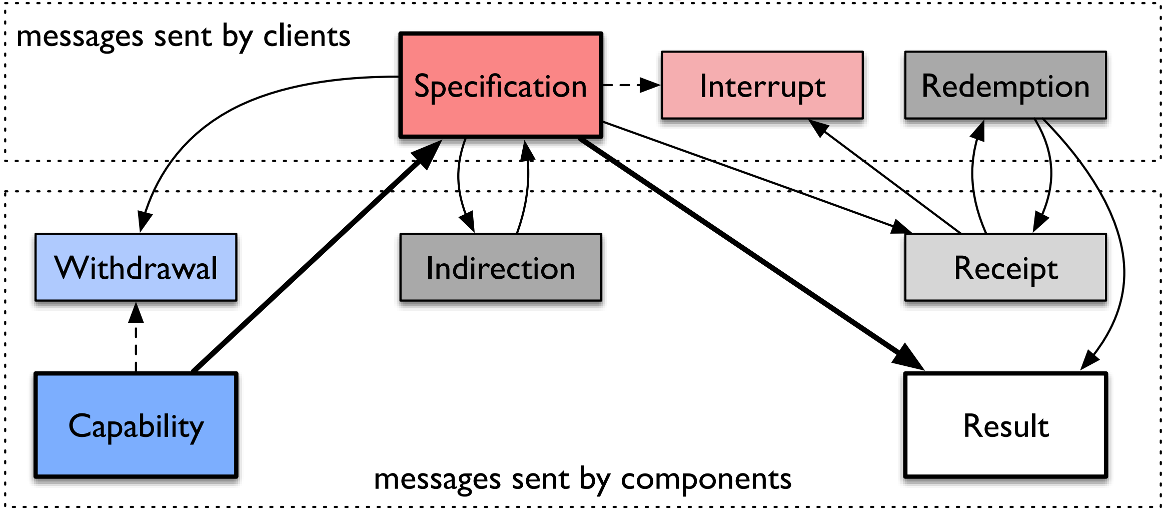
Weak imperativeness

- **Failure is inevitable. Embrace it.**
- Two kinds of failure:
  - Things that are part of what you're measuring (e.g. variable connectivity on mobile probes)
  - Things that need a forklift to fix.
- For the second class, you need completely separate infrastructure monitoring anyway.
- For the first class, export enough metadata to allow analysis *as part of the normal measurement workflow.*

The mPlane Protocol

- Error-tolerant, distributed RPC protocol comprised of an information model (message types and contents), a representation (JSON), and a session protocol (HTTPS)
  - Flexibility in future representation (e.g. CBOR) and session protocols (e.g. WebSockets, SSH).
- Under submission to IETF for standardization (`draft-trammell-mplane-protocol`)

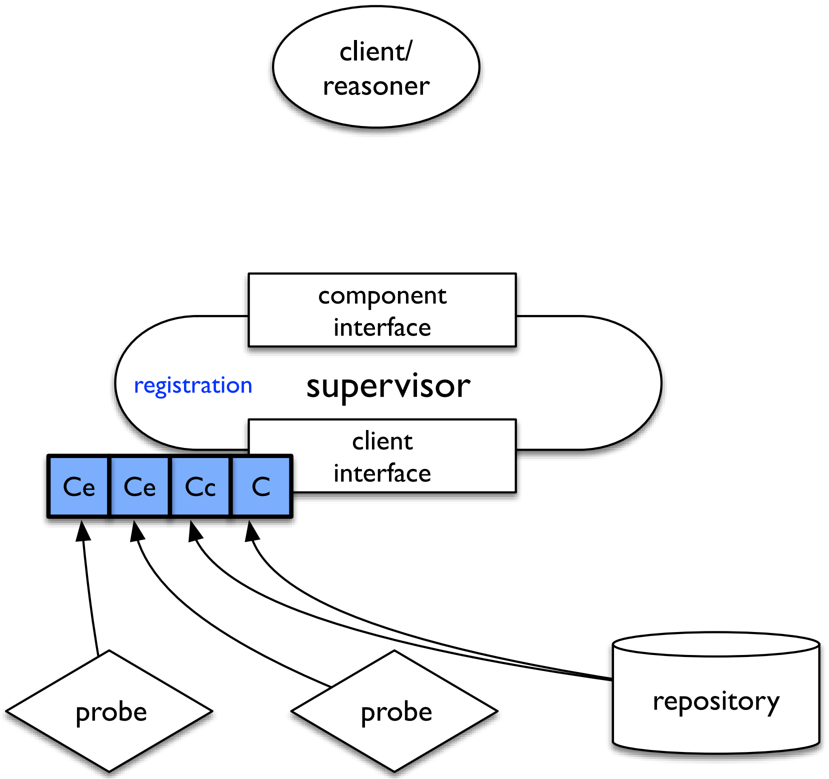
what a client wants a component to do



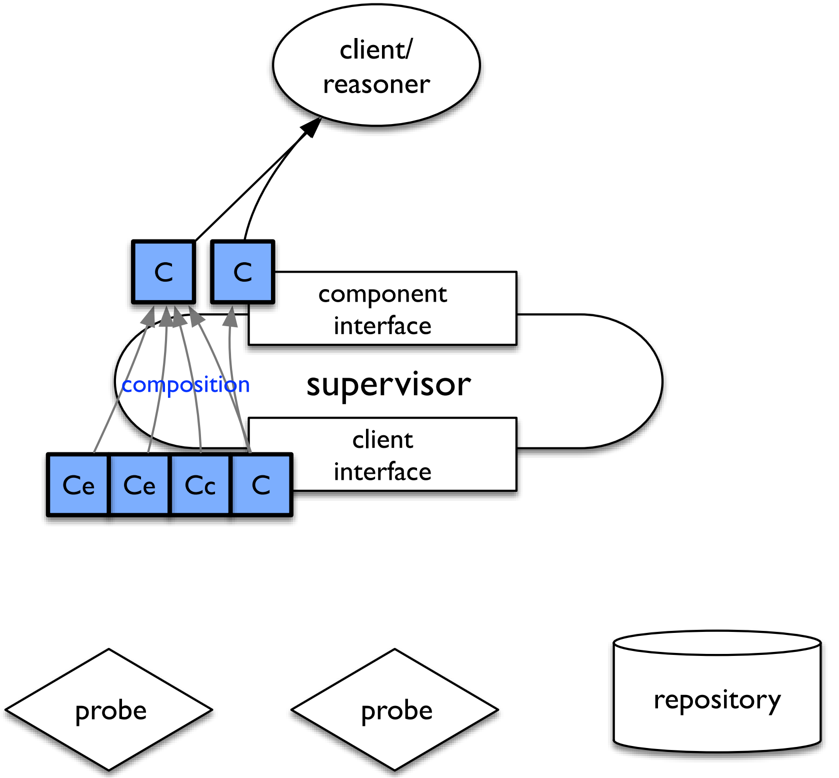
what a component says it can do

what the component did

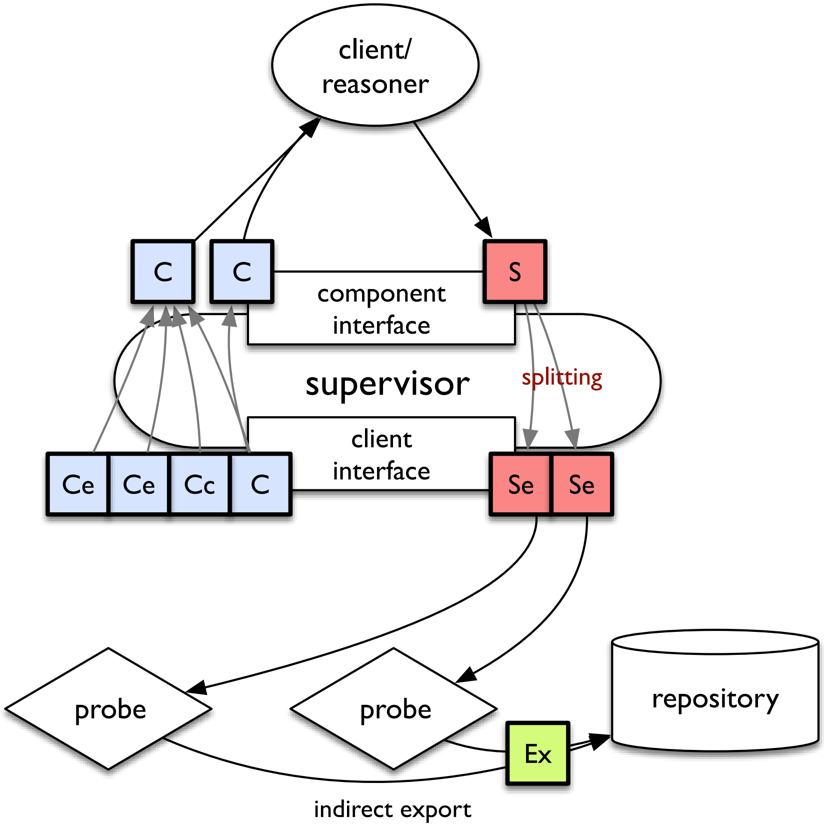
Capability Advertisement



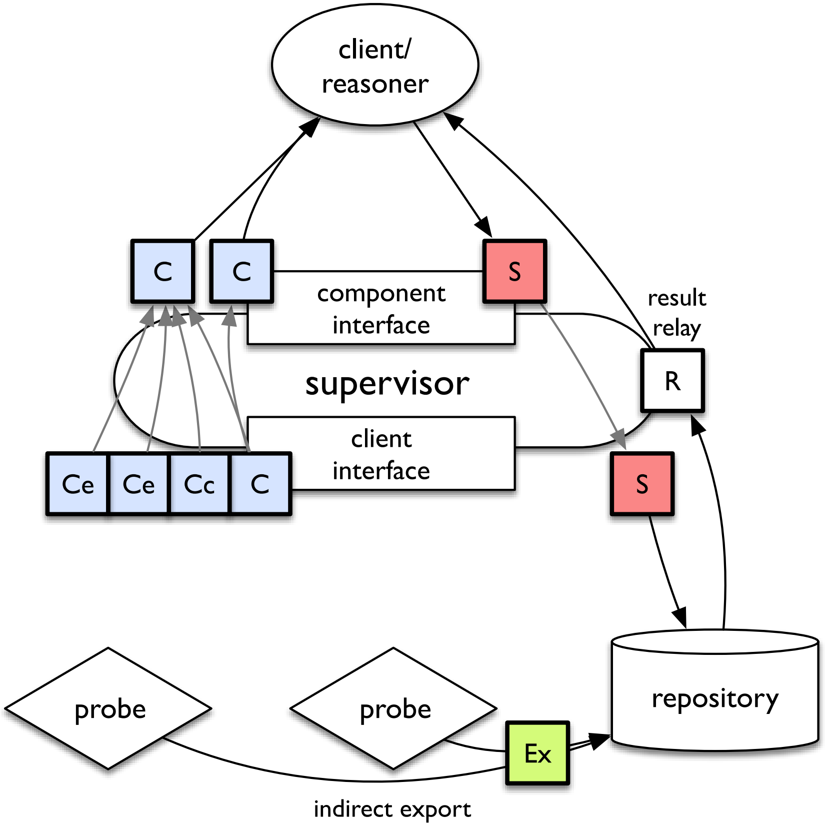
Capability Composition



Delegation

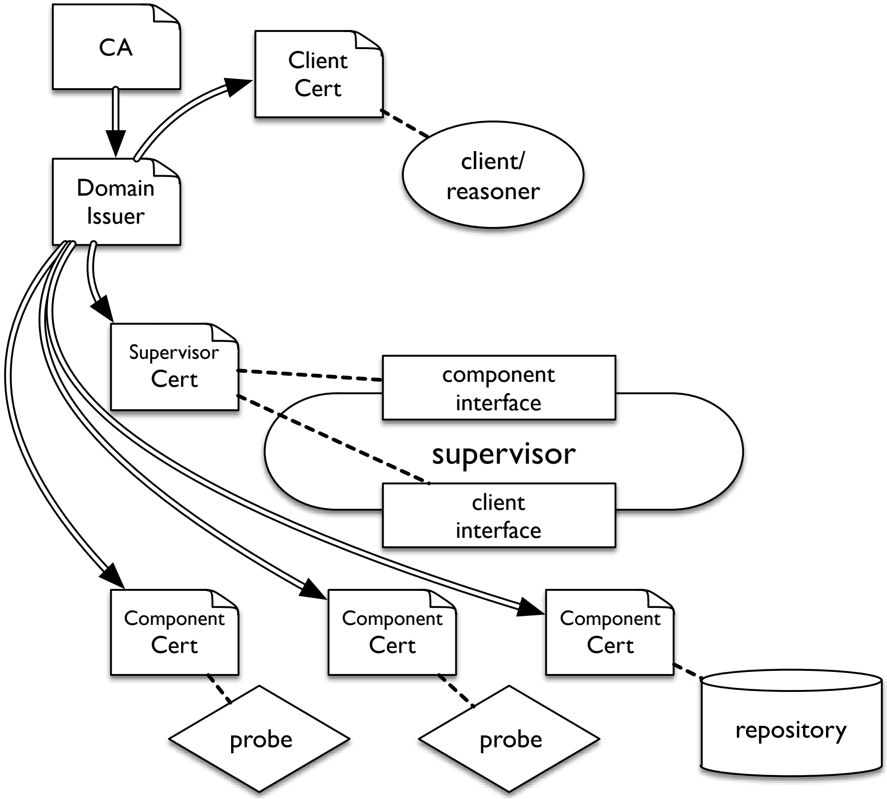

client/
reasoner
C
C
S
component
interface
supervisor
splitting
client
interface
Ce
Ce
Cc
C
Se
Se
probe
probe
Ex
repository
indirect export

Query and Iteration



An mPlane Domain

- mPlane clients and components organized into domains by:
  - ❑ which supervisor (if any) they use for coordination and federation
  - ❑ common issuer of X.509 certificates for all entities in a domain



Capability Example

```
{
    "capability" : "measure",
    "version":     1,
    "registry":    “http://mplane.corvid.ch/ecnspider.json”,
    "label":       "ecnspider-ip4",
    "when":        "now ... future",
    "parameters" : {
        "source.ip4": “192.0.2.33”,
        "destination.ip4": "[*]",
    },
    "results": [
        "destination.ip4",
        "ecnspider.ecnstate",
        "connectivity.ip",
        "octets.layer5",
        "ecnspider.initflags.fwd",
        "ecnspider.synflags.fwd",
        "ecnspider.unionflags.fwd",
        "ecnspider.initflags.rev",
        "ecnspider.synflags.rev",
        "ecnspider.unionflags.rev"
    ]
}
```

- Case study: path transparency measurement for ECN
- Each component advertises its willingness to perform a specified measurement in a capability
- Capability lists parameters (which the client needs to fill in) and results (which the component will measure)

Capability Schema

```
{
    "capability" : "measure",
    "version":     1,
    "registry":    “http://mplane.corvid.ch/ecnspider.json”,
    "label":       "ecnspider-ip4",
    "when":        "now ... future",
    "parameters" : {
        "source.ip4": “192.0.2.33”,
        "destination.ip4": "[*]",
    },
    "results": [
        "destination.ip4",
        "ecnspider.ecnstate",
        "connectivity.ip",
        "octets.layer5",
        "ecnspider.initflags.fwd",
        "ecnspider.synflags.fwd",
        "ecnspider.unionflags.fwd",
        "ecnspider.initflags.rev",
        "ecnspider.synflags.rev",
        "ecnspider.unionflags.rev"
    ]
}
```

- The verb and set of parameters and results together define the measurement’s *schema.*
- The schema is equivalent to the name of the RPC entry point.

Registry Extensibility

```
{
    "capability" : "measure",
    "version":     1,
    "registry":    “http://mplane.corvid.ch/ecnspider.json”,
    "label":       "ecnspider-ip4",
    "when":        "now ... future",
    "parameters" : {
        "source.ip4": “192.0.2.33”,
        "destination.ip4": "[*]",
    },
    "results": [
        "destination.ip4",
        "ecnspider.ecnstate",
        "connectivity.ip",
        "octets.layer5",
        "ecnspider.initflags.fwd",
        "ecnspider.synflags.fwd",
        "ecnspider.unionflags.fwd",
        "ecnspider.initflags.rev",
        "ecnspider.synflags.rev",
        "ecnspider.unionflags.rev"
    ]
}
```

- Each measurement is bound to a registry of elements.
- Registries inherit elements from the base registry.
- Here, ECN-specific elements have been added.

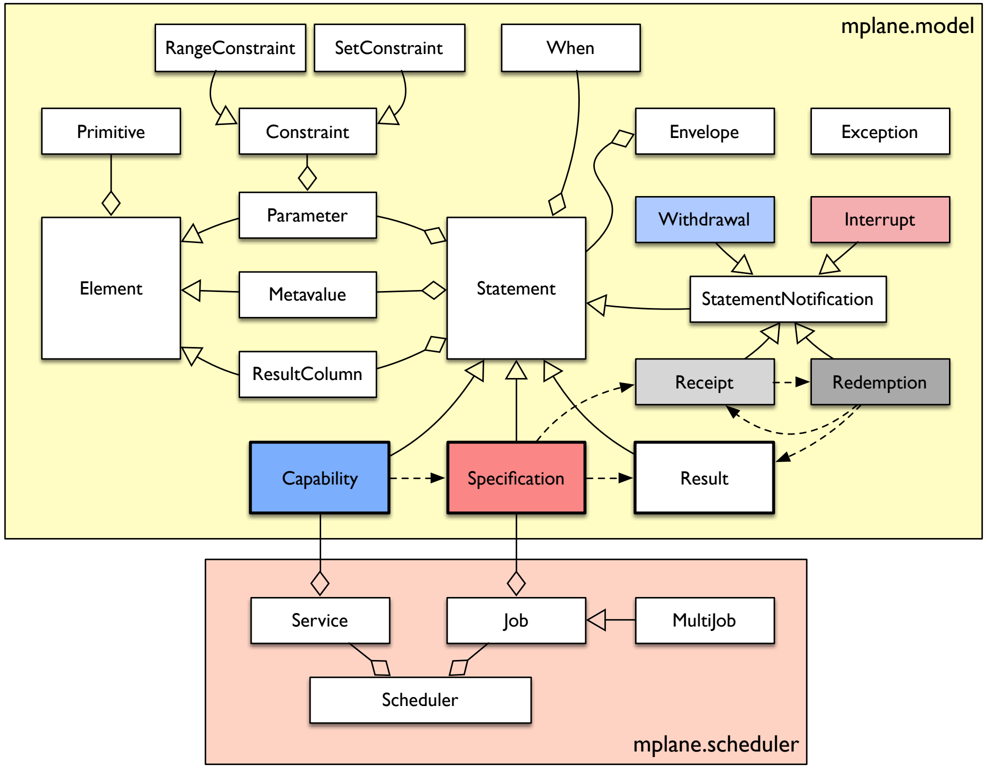
Specification Example

```
{
    "specification" : "measure",
    "version":     1,
    "registry":    “http://mplane.corvid.ch/ecnspider.json",
    "label":       "ecnspider-ip4",
    "when":        "now”,
    “token”:       “d41d8cd98f00b204e9800998ecf8427e”,
    "parameters" : {
        "source.ip4": “192.0.2.33”,
        "destination.ip4": [
            “192.0.2.67”,
            “192.0.2.89”,
            “192.0.2.123”]
    },
    "results": [
        "destination.ip4",
        "ecnspider.ecnstate",
        "connectivity.ip",
        "octets.layer5",
        "ecnspider.initflags.fwd",
        "ecnspider.synflags.fwd",
        "ecnspider.unionflags.fwd",
        "ecnspider.initflags.rev",
        "ecnspider.synflags.rev",
        "ecnspider.unionflags.rev"
    ]
}
```

- Specification completely defines the measurement to be performed
- Client sends a list of targets to each component.
- Component will return a single *result* per specification.

mPlane SDK

- Open-source toolkit for building mPlane clients and components in Python 3
  - `$ pip install mplane-sdk`
- Current release: feature freeze for today's demos
- 1.0 release: post-project
  - improved configuration
  - multiple value support



mPlane SDK component/client framework

- mplane/component.py provides a framework for building components and proxies for existing components in three easy steps:
  - (1) Implement logic for each activity in `run()` method in a subclass of `mplane.scheduler.Service.`
  - (2) Build capabilities to describe the specifications this `run()` method will accept.
  - (3) Wrap these in a Python module that returns these subclasses via a `services()` method.
- Common and component-specific configuration via a unified configuration file

How do I get started?

- https://github.com/fp7mplane/protocol-ri
  - `README.md`: how to build stuff on top of the SDK
  - `doc/protocol-spec.md`: protocol specification

- Repository is active
  - `master` branch stable for demonstration
  - 1.0 release in `sdk-rc1.0` branch
  - Something broken? read the docs, then file an issue.