Distributed Network Management

How does scripting affect management architectures?

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Structure of the Talk

1. Background Information
2. Network Management Architectures
3. Management By Delegation
4. ISO Command Sequencer
5. IETF DISMAN Script MIB
6. Script MIB Implementation Issues
7. Impact and Future
8. Discussion

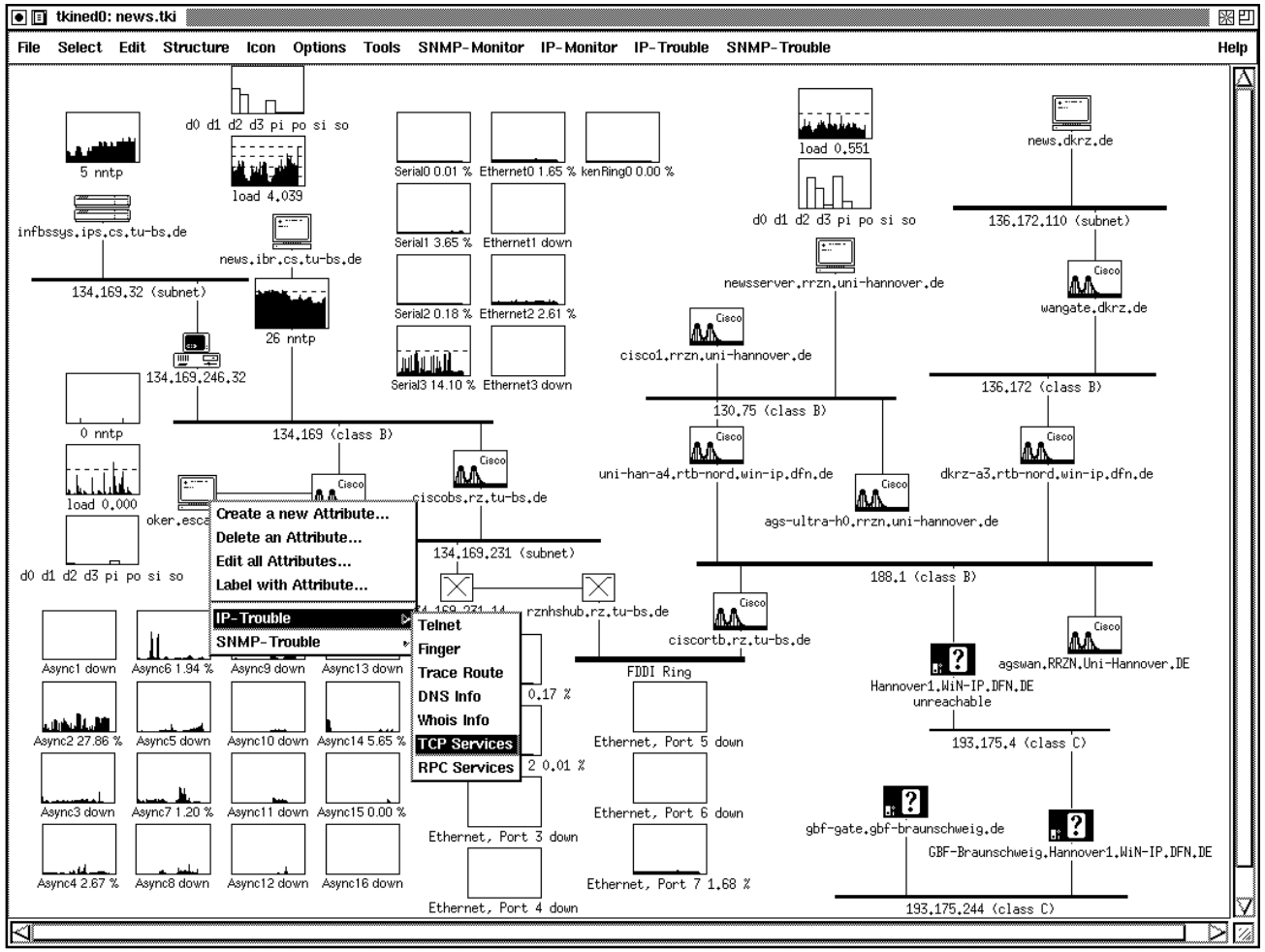
1990:

- Masters degree in computer science from TU Braunschweig, Germany.
- Thesis about an expert system for sewage plants (constraint systems, smalltalk).

1991-1994:

- Network management (NM) recognized as a challenging problem of future computing and communication systems.
- Development of simple prototypes to get practical experience.
- Every network has different management needs.
- NM systems must be flexible to allow adaptations to side specific needs.
- Work on security issues, especially authentication protocols.
- Design and implementation of a "management toolkit" based on Tcl.
- Goals: efficiency, flexibility, portability.
- First prototype presented on the CeBIT '94 computer exhibition.
- Implementation (source code) released to the public for general use.

GUI of the network management toolkit



1995-1996:

- Mechanisms to distribute (delegate) management functions dynamically in the form of management scripts.
- Goals: robustness, reliability, security.
- Mechanisms: group communication on top of SNMP, election protocols, user based security for SNMPv2.
- Maintenance and evolution of the network management software package.

1996-1997:

- Post-doc position (1 year) at the University Twente, Netherlands.
- Management software package ported to Windows NT.
- Active member and contributor to IETF working groups:
  - distributed network management (DISMAN)
  - application management (APPLMIB)
- Prototypes for the management of WWW services and servers.
- Prototypes for using the WWW as part of management systems.

The Variable-Oriented Approach (Pras 1995)

Description:

- Manager operates on variables within a managed system.
- Primitive operations are get and set.
- SNMP is the prominent example of this approach.

Characteristics:

- Manager does not specify the goals of a management operation but the means (steps) to reach the goals.
- Most management functions will be performed by managing systems and only a few by managed systems.
- Inefficient in respect to bandwidth (moving data to applications).
- Interactions with little expressive power (micro-management).
- Agent does not understand the purpose of management operations.

The Command-Oriented Approach (Pras 1995)

Description:

- Manager issues imperative commands.
- Each command has well-defined semantics.
- Token-Ring management is an example.

Characteristics:

- Manager specifies the goal of an operation and not how the managed system should reach the goal.
- More complex functions are performed by the managed system.
- Management applications have less complexity and are easier to build.
- Managed systems get (a) more complex for simple operations and (b) less complex for complex operations.
- The semantics of the commands are defined at design/implementation time which leads to a lack of flexibility in the operational phase.

The Object-Oriented Approach (Pras 1995)

Description:

- Manager operates on so-called objects which encapsulate state and behavior.
- OSI management is the prominent example.

Characteristics:

- Attributes of managed objects can be seen as variables.
- Methods of managed objects can be seen as commands.
- The OO approach is a hybrid combination of the VO and CO approach.
- The OO approach allows to structure variables and command in order
  a) to provide clear and consistent definitions of managed objects and
  b) to encourage controlled re-use of specifications.

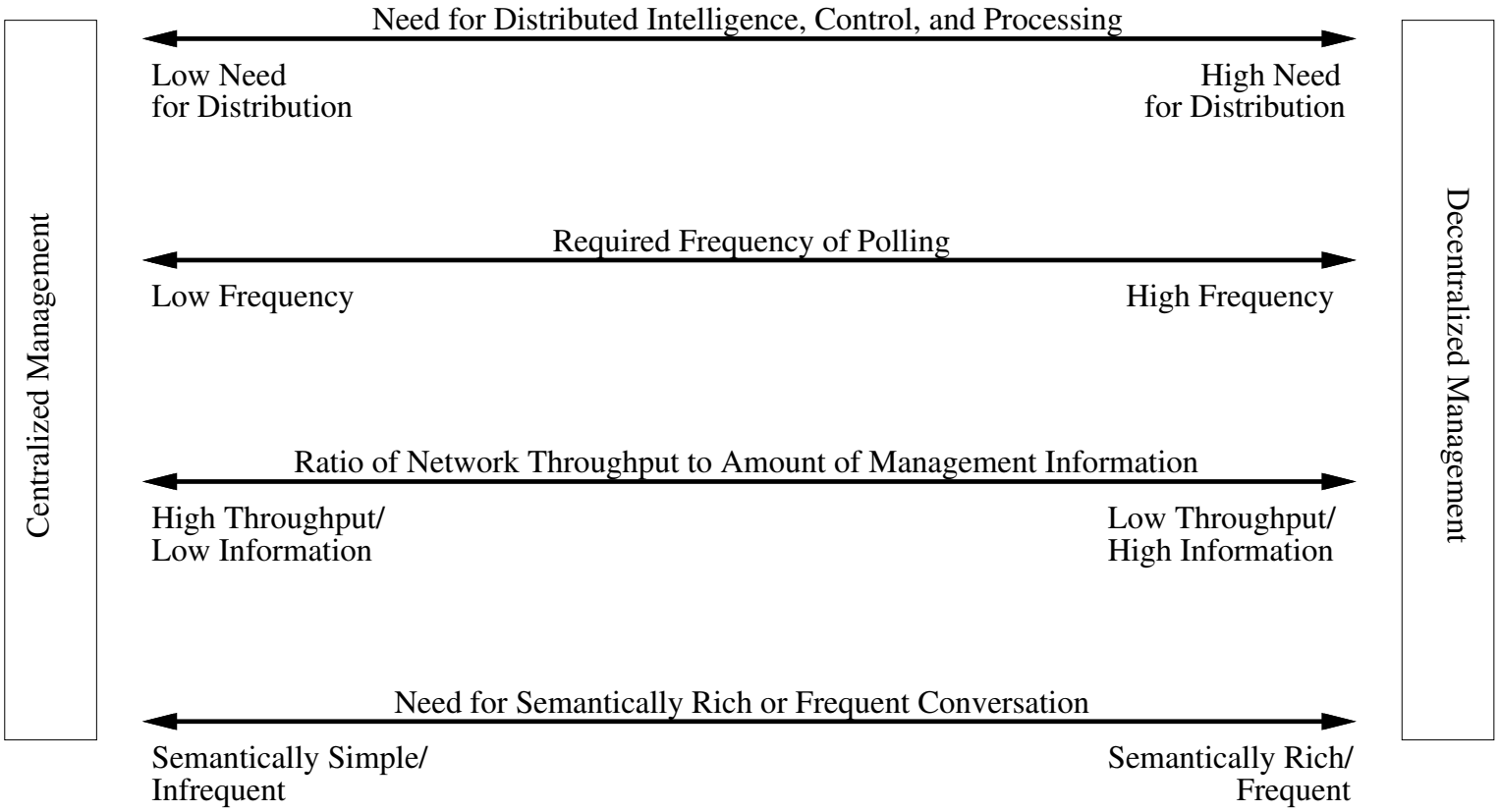
Distributed Management in the OSI Architecture:

- Implementation of management functions as part of powerful agents:
  (e.g. Workload Monitoring Functions, Summarization Functions)
- Control and/or discriminator objects are used to parameterize management functions.

Distributed Management in the Internet Architecture:

- Specialized agents or management stations acting in a dual role:
  (e.g. Remote Network Monitoring (RMON), Manager-To-Manager MIB)
- Tables contain parameter sets to control the activities of an agent.
- Algorithms can be defined to interpret tables as rule sets (NeTraMet).

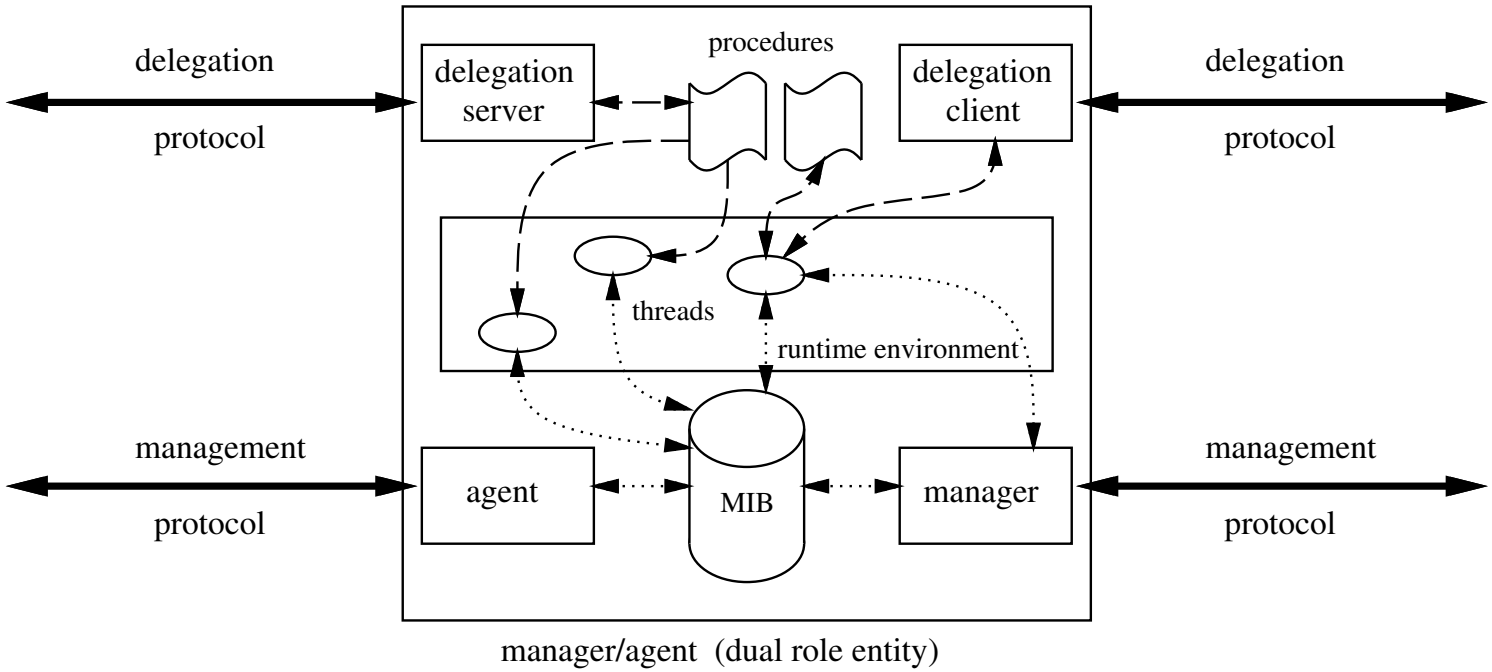
Centralized versus Distributed Management (Meyer et. al. 1995):



Management by Delegation (Yemini, Goldszmidt 1991)

- Smart agents with the ability to execute management scripts written in a management scripting language (MSL).
- Manager distributes management scripts to agents in order to expand their functionality at run-time (remote evaluation, mobile code).
- Delegated management scripts operate in local environments and reduce the amount of management information moved over (expensive) networks.
- Delegated scripts operate independent of the manager (self-managing or self-healing networks).
- Manager is concerned with the management of delegated scripts.

Internal Structure of an MbD Implementation



Design Issues

Delegation Protocol:

management protocol	$\longleftrightarrow$	special purpose protocol
manager "push" (procedures)	$\longleftrightarrow$	agent "pull" (procedures)
agent "push" (results)	$\longleftrightarrow$	manager "pull" (results)

Language:

interpreted language	$\longleftrightarrow$	compiled language
standard language	$\longleftrightarrow$	domain specific language

Procedures:

MIB object arguments and results	$\longleftrightarrow$	arbitrary argument and result types
activation by events/scheduler	$\longleftrightarrow$	activation by manager

Runtime:

multiple manager, multiple languages	$\longleftrightarrow$	single manager, single language
multiple threads	$\longleftrightarrow$	event driven
error and status monitoring objects	$\longleftrightarrow$	notifications
multiple security profiles	$\longleftrightarrow$	no security

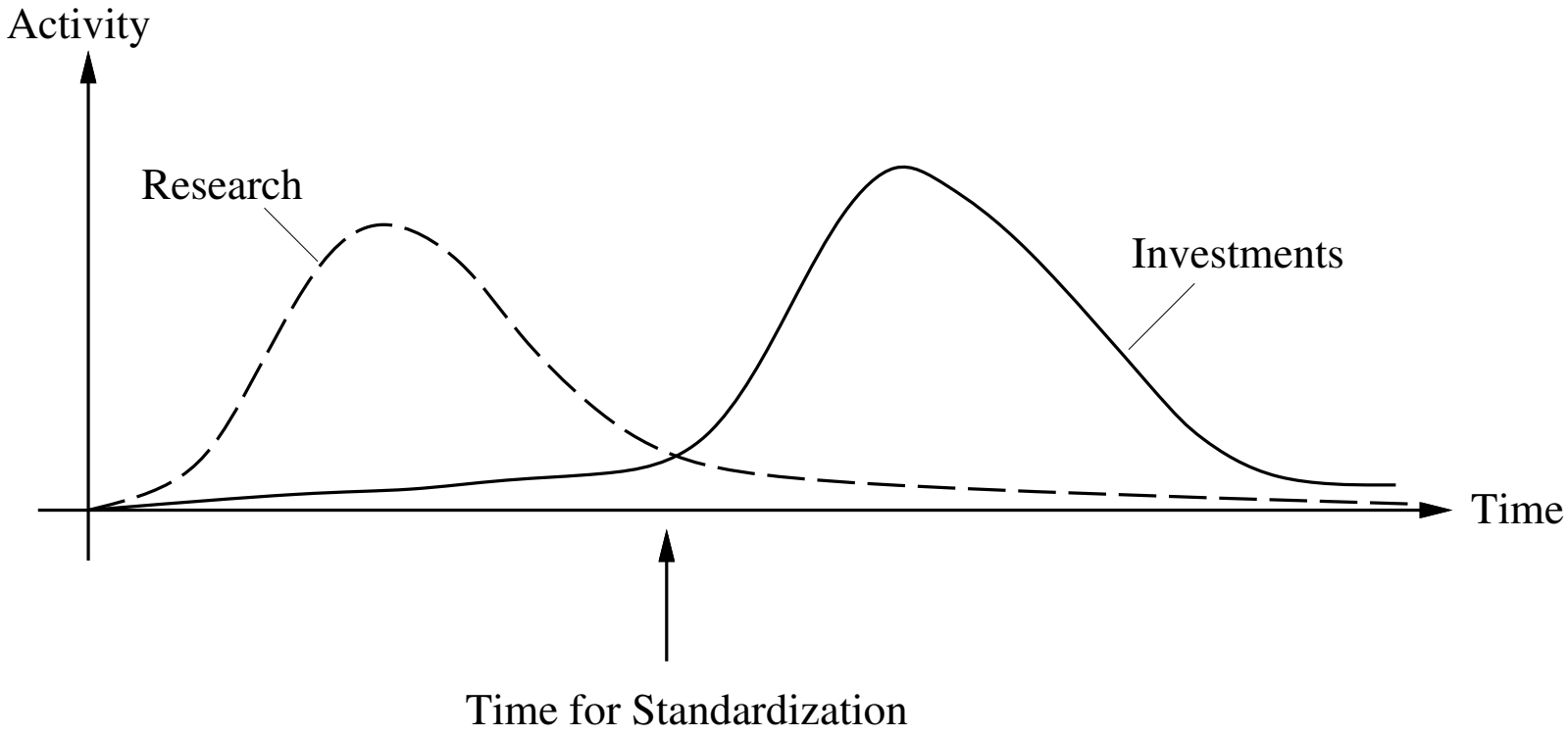
From Research Prototypes ...

- 1991–1995: Management By Delegation (Columbia University)
- 1993–1995: Script Language & MLM MIB (SNMP Research)
- 1994–1996: NMP Stack Language (TU Vienna)
- 1995–1996: MbD with Security & Cooperation (TU Braunschweig)

... Towards Standards:

- 1996–199?: Script MIB (IETF DISMAN WG)
- 1996–199?: Command Sequencer (ISO 10164-21 WG)

Theory of Standardization (David Clark, MIT)



ISO Standardization (ISO 10164-21)

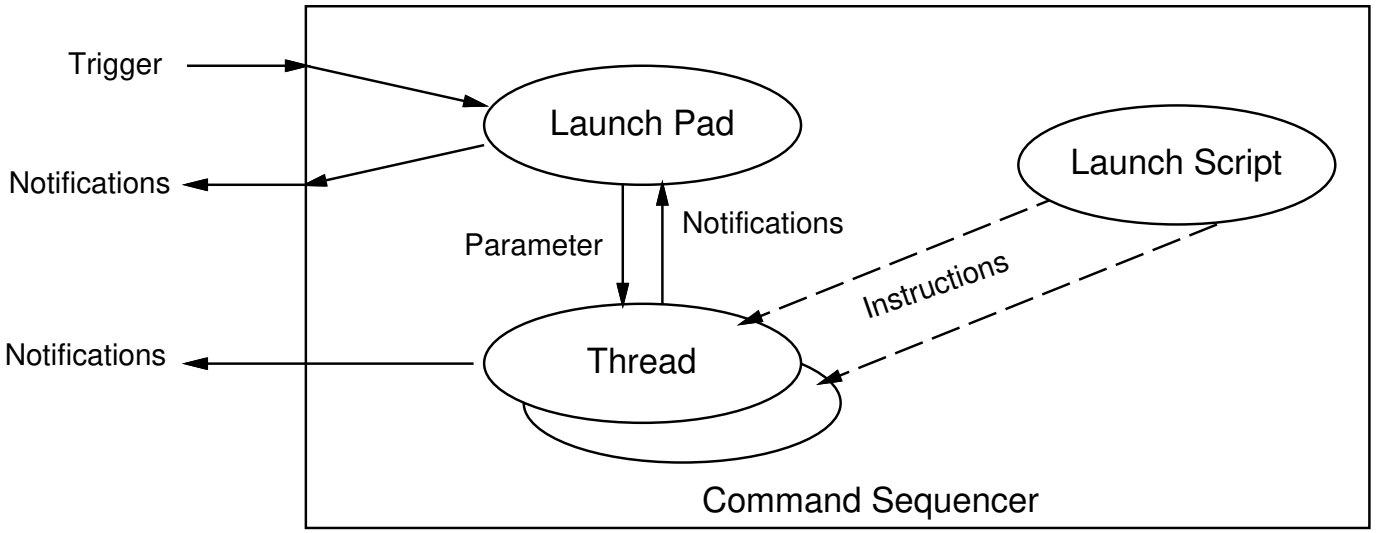
User Requirements:

- Allow the delegation of management activities.
- Reduce the amount of communication that between manager and agents.
- Allow delegated systems to operate when communication have been disrupted.
- Provide flexible control of management activities.
- Provide a scripting language which can describe management procedures.
- Allow delegated systems to execute CMIS operations in sequence.

Operational Requirements:

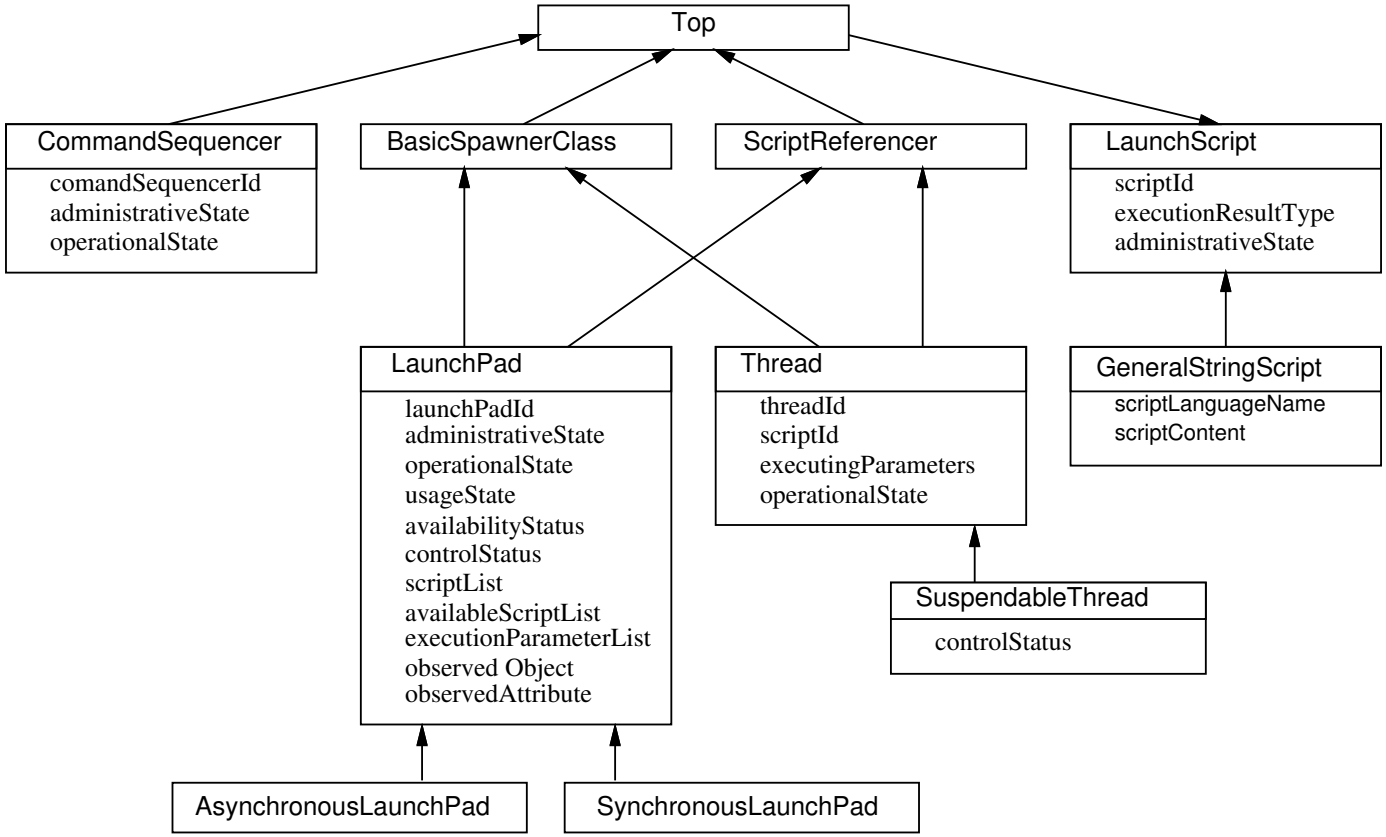
- Pre-scheduled or delayed execution of a systems management operation.
- Capabilities for modifying the request for pre-scheduled or delayed execution.
- Capabilities for initiating, suspending, resuming and terminating management operations based on time management actions or the occurrence of events.
- Capabilities for reporting/recording outcome of scheduled or delayed execution.
- The ability to send notifications when state changes occur.

ISO Command Sequencer Model



- Launch pad objects start the execution of launch scripts on receiving a trigger.
- A trigger can be an external event or the result of a scheduling function.
- A script is executed by a launch pad by means of one or more thread objects.
- Synchronous launch pads return trigger results after thread termination.
- Asynchronous launch pads distinguish between trigger and execution results.

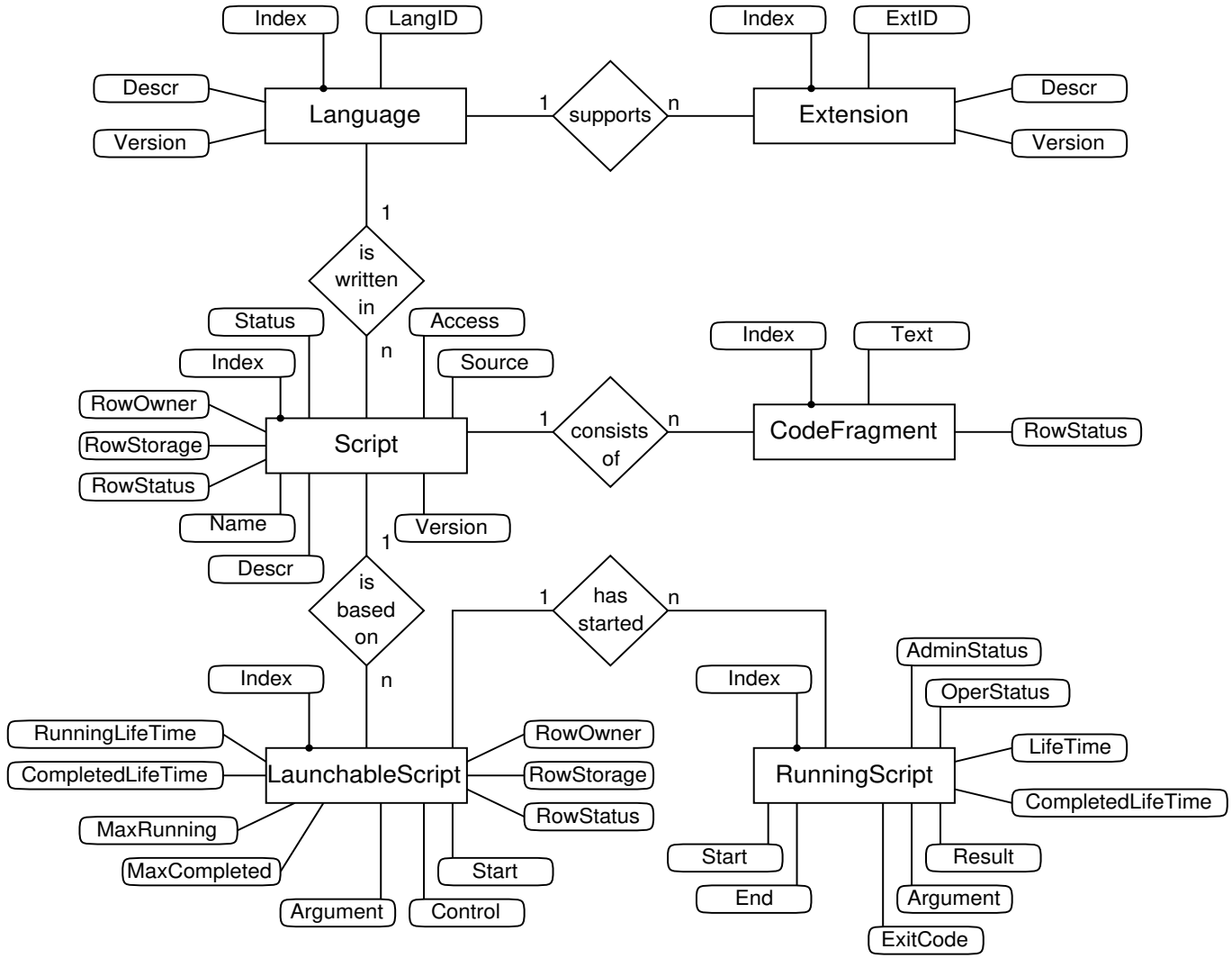
ISO Command Sequencer Classes



IETF Standardization (DISMAN WG)

DISMAN services extend the Internet management framework:

Known Systems:	Access and configure the set of known systems.
Management Domains:	Derive target lists for management operations.
Scheduling:	Activate management operations.
Notifications and Logging:	Handling of received or emitted notifications.
Delegation Control:	Protect DISMAN systems and managed networks.
Scripting:	Download and control of management scripts.
Expression and Thresholds:	Computations on MIB objects.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RowStatus
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LifeTime
CompletedLifeTime
Start
End
Result
Argument
ExitCode

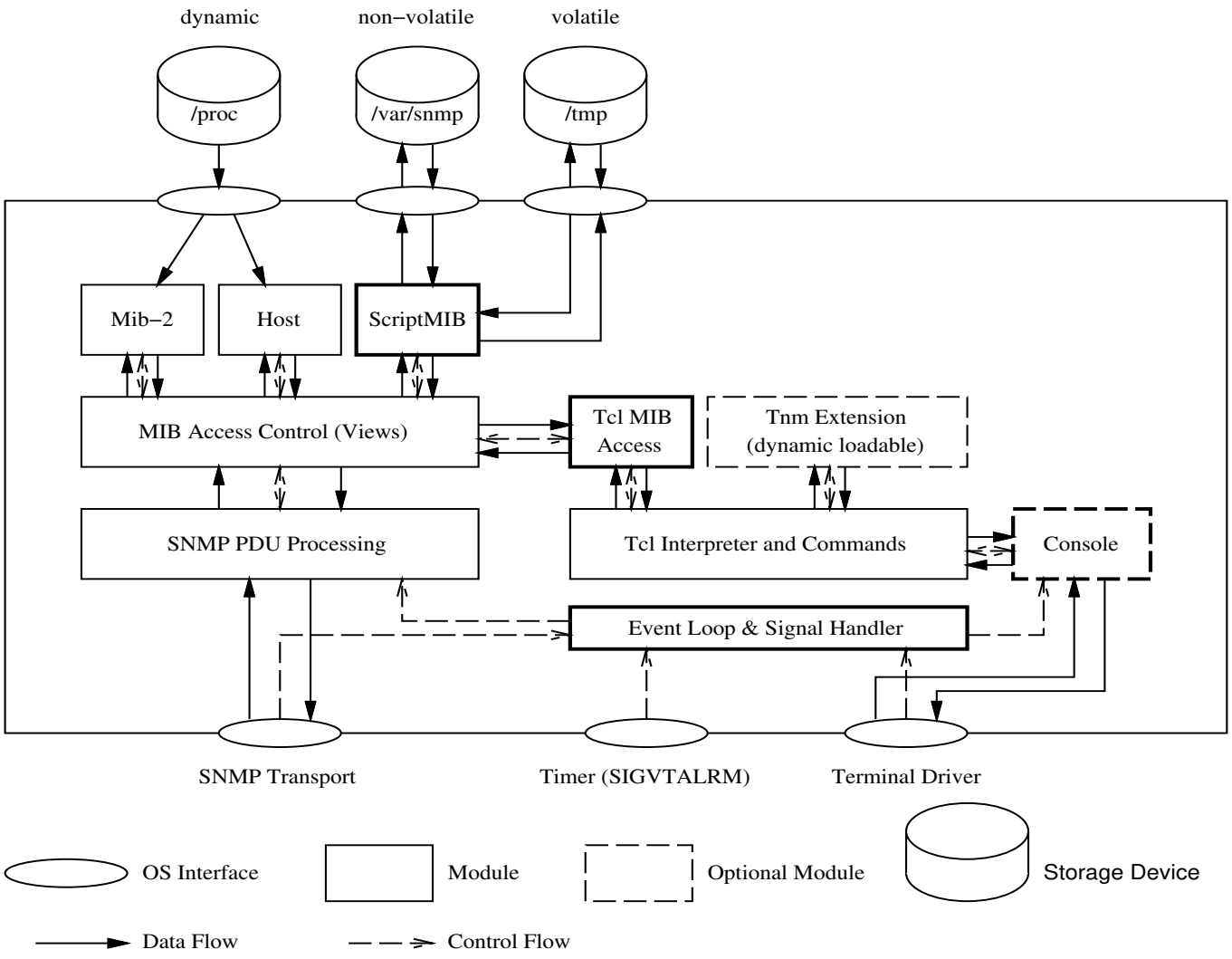
Implementation of the Script MIB (in progress)

Major Design Issues:

- Selection of scripting language. ($\Rightarrow$ Tcl)
- Selection of process model. ($\Rightarrow$ event-driven, single process, single thread)
- Selection of SNMP environment. ($\Rightarrow$ Linux SNMP agent)

Major Work Items:

- Language interface to access local SNMP agent.
- Language interface to access remote SNMP agents.
- Implementation of the Script-MIB variables and tables.
- Organization of non-volatile storage.
- Internal scheduling and event handling (expiration of table entries etc.)


dynamic
non−volatile
volatile
/proc
/var/snmp
/tmp
Mib−2
Host
ScriptMIB
MIB Access Control (Views)
Tcl MIB Access
Tnm Extension (dynamic loadable)
SNMP PDU Processing
Tcl Interpreter and Commands
Console
Event Loop & Signal Handler
SNMP Transport
Timer (SIGVTALRM)
Terminal Driver
OS Interface
Module
Optional Module
Storage Device
Data Flow
Control Flow

IETF Script MIB Status

Script MIB Issues:

- Open security and access control issues.
- How to model script privileges and runtime profiles?
- Interactions with generic event services and scheduling of scripts.

Possible impact on the IETF management framework:

- The Script MIB adds a standard interface for command-oriented network management to the variable-oriented SNMP framework.
- Scripts are much more flexible than command-oriented systems because they can be modified anytime.
- Is there a need and a way to standardize scripts (= complex management function) in addition to SNMP MIBs in the future?

The Script-Oriented Approach

Description:

- Management operations are performed by scripts that are delegated to managing or managed systems in the network.
- Scripts can be created and modified easily during the operational phase.

Characteristics:

- Scalable management operations (scripts can be adapted to the processing power of the target system).
- Flexibility since management functions can be added and changed at any time.
- Allows managing systems to perform complex "transactions" without paying high costs for correct error handling.
- Introduces a new control problem which needs to be handled.

Possible work items for the future:

- Design domain specific scripting languages which work well for network management purposes.
- Build freely available prototypes to encourage people to experiment with this approach to handle network management problems.
- Create an archive of useful scripts for common management problems.
- Compatibility with and support for SNMPv1, SNMPv2c and SNMPv3.
- Support and integration into other technologies (CORBA).
- Work on security, access control, robustness, ...
- Integration and experiments with new technologies (Web, VR, ...).