NGAC policy tool, policy server, and EPP Release Note for v0.4.3++ snapshot, 8 May 2020

1. SUMMARY OF V0.4.3[1]

This version of the TOG NGAC Policy Tool and Policy Server includes new features that represent the merging of requirements from several use cases. The implementations of these features are in various stages of completion in this version. The recent and new features and their current status in this version are:

- Policy graph output – is experimental and needs further development of heuristics for layout of policy graphs
- Policy specification output
- Timing commands for performance testing
- Global policies for clouds-of-clouds and a corresponding query API
- Refactored source code to closely follow the high-level architecture
- Event Processing Point and commands to start EPP
- Event-Response Language (ERL) to configure the EPP
- New EPP interface API
- Conditional policy extensions to the Declarative Policy Language (DPL)
- Condition variables to support conditional policies
- Linkage to external Context Management and Extraction subsystem for context information
- Extensions for policy update by a distributed ledger
- Additional policy administration commands
- --jsonresp command line option to cause JSON responses from all Policy Server or EPP APIs. The default is the original plain text style.

All JSON responses are of the form:

```
{
   "respStatus" : <statusType>,
```

[1] This document describes the development version v0.4.3. Some of the features are new and not exhaustively tested and some features specified in this document may not yet be completely implemented.

"respMessage" : <statusDesc>,
"respBody" : <statusBody>
}

where <statusType> is “success” or “failure”; <statusDesc> and <statusBody> are specific to the API and depending on whether the respStatus is “success” or “failure”.

2. THE NGAC POLICY TOOL AND POLICY SERVER

The NGAC functional architecture presented in the standard is shown in Figure 1. PEP is Policy Enforcement Point, RAP is Resource Access Point, PDP is Policy Decision Point, PAP is Policy Access/Administration Point, PIP is Policy Information Point, and the optional EPP is Event Processing Point.

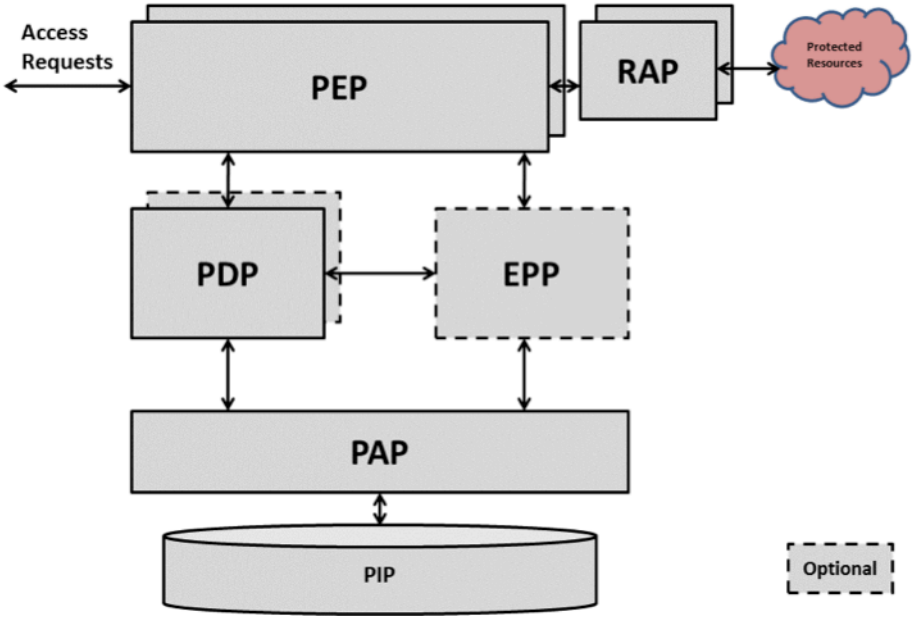


Figure 1 NGAC functional architecture per the standard

The Open Group's version of the functional architecture differs from the version presented in past NGAC documents and standards in that it "unbundles" the PEPs and RAPs from the NGAC perimeter as shown in Figure 2. This is a response to our practical experience with getting application developers to adapt their code to use NGAC to access their resources. It is not practical to modify the NGAC implementation every time it is desired to add new protected object class access methods. This architecture enables a more extensible implementation of NGAC by easing the addition of new protected object kinds. The figure also shows our newly added EPP, enhanced Policy Tools and Languages, and interface to the Context Monitoring and Extraction system.

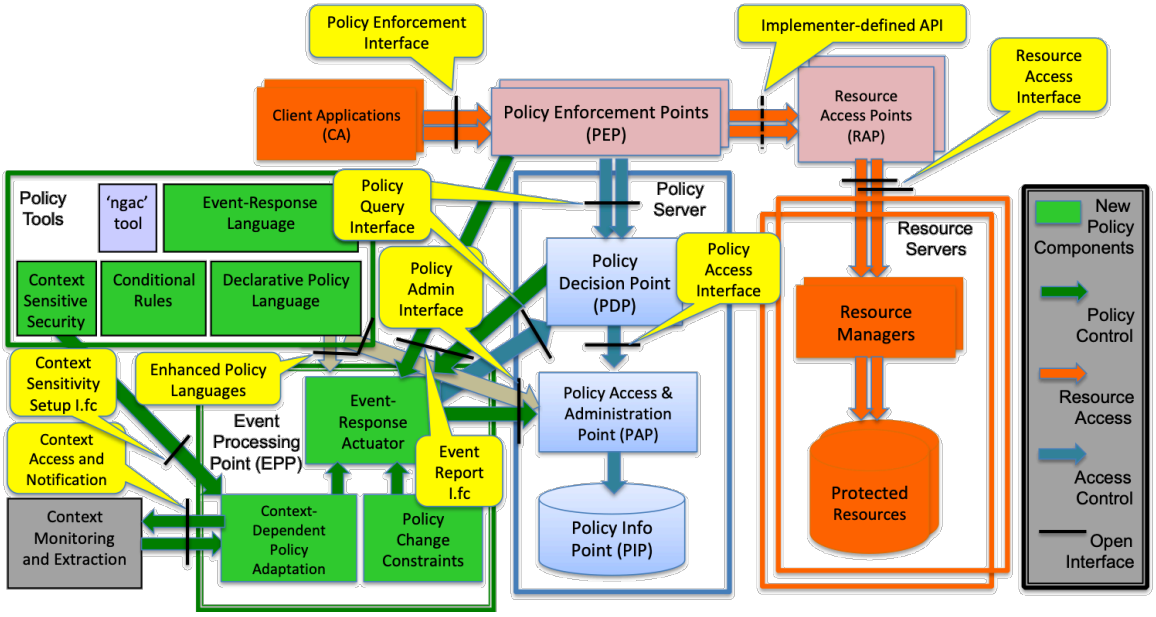


Figure 2 Our NGAC functional architecture with EPP and "unbundled" PEP & RAP

In The Open Group's approach the developer creates appropriate PEP and RAP components for new object classes or access methods following simple templates, resulting in separate small and trusted[2] PEP and RAP components. The PEP template includes calls to the Policy Server through the RESTful Policy Query Interface. Besides marshalling and de-marshalling communication parameters, the PEP consists of a single decision based on calling the Policy Server (PDP) and either returning an error condition to its caller if the PDP returned **deny**, or calling the RAP and completing the access operation if the PDP returned **permit** (or **grant**).

The Open Group has pursued design and implementation our own NGAC-related tools and a straightforward declarative language to express policies that comply with the NGAC framework. Specifically, a desktop command-line policy tool called 'ngac' loads policies expressed in the declarative language and can answer queries such as "access(policy1,(u1,r,o2))", the meaning of which is: "under policy 'policy1', is user 'u1' allowed to read object 'o2'?".

As part of the design effort of the PHANTOM project we investigated the feasibility of implementing a portable server to include the PDP/PAP/PIP functions. Through design and experimental implementation we concluded that a full heavyweight implementation of a portable server based on a database management system for the PIP, as was the case for a reference

[2] What makes the components *trusted* is the role they play in the architecture; what makes them *trustworthy* is a combination of their isolation as separate components, their distinct keys for trusted channel communication, their simplicity, and their construction from approved well-developed templates.

implementation of the standard, would be too costly for the project. However, we did discover that we could develop a functional lightweight and portable implementation, the design of which is described in the following.

We expanded our implementation of our first simple policy tool and designed and implemented a server with RESTful APIs for the PEP-to-PDP interface, which we call the Policy Query Interface. The PEP only needs to call the PDP through this interface with an access query that the PDP answers with "permit" or "deny". Based on this response the PEP must not perform the access to the RAP (if "deny"), or proceed to perform the object access and return the result to the application. The PEP is fundamentally a trivial decision statement conditioned by the PDP's response that performs the access on one path, or reports an error on the other path.

3. ENHANCED DECLARATIVE POLICY SPECIFICATION LANGUAGE

The declarative language representation is easily constructed from a graphical representation of a policy. The present declarative language does not support the entire NGAC policy framework (lacking prohibitions and obligations) though it is our ambition to add them incrementally in the future as need may require.

The enhanced declarative policy language supports policy composition and the definition of new object classes and operations.

A declarative policy specification is of the form:

policy(<policy name>, <policy root>, <policy top elements>).

where,

<policy name> is an identifier for the policy definition

<policy root> is an identifier for the policy class defined by this definition

<policy top elements> is a list [*< policy t-element>, ... , < policy t-element>*]

<policy t-element> is *<element>* or *<cond element>* or *<conditions declaration>*

where *<element>* is one of:

user(<user identifier>)

user_attribute(<user attribute identifier>)

object_class(<object class identifier>, <operations>)

object(<object identifier>)

object(<object identifier>, <object class identifier>, <inh>, <host name>,
<path name>, <base node type>, <base node name>)

object_attribute(<object attribute identifier>)

policy_class(<policy class identifier>)

composed_policy(<new policy name>, <policy name1>, <policy name2>)

operation(<operation identifier>)

opset(<operation set identifier>, <operations>)

assign(<entity identifier>, <entity identifier>)

associate(<user attribute id>, <operations>, <object attribute id>)

where <*operations*> is a list:

[<*operation identifier*>, ... , <*operation identifier*>]

connector('PM')

An extension to the declarative policy language, as <*policy top element*> above, is made for conditional elements. Motivated by the objective of adding context-dependency to policy rules, it is nonetheless defined as a general mechanism of rules activated by a defined set of conditions which may be based on a set of identified condition variables. For context sensitivity, context variables may serve as condition variables, and condition predicates may be defined that are dependent on the present value of the context variables.

The extension is defined to have two potential forms. Every implementation is required to provide the first form, the second form being optional and not implemented in Cross-CPP. The first of these forms is realised as a conditional element, <cond element>. The form of a <cond element> is:

cond(<condition>, <element>)

or

cond(<condition>, <policy elements>)

where <*element*> is as defined previously, and

<*policy elements*> is a list [<*element*>, ... , <*element*>]

Note that this definition of <*cond element*> does not admit nested conditional elements, that is <*cond element*> can only occur as a <*policy top element*>.

The second form of the conditional element extension permits any single assign or associate policy <element> above to have the following suffix:

if <condition>

where <*condition*> is a predicate that may involve condition (context) variables.

In this form, the absence of the suffix in a policy element is the same as: *if TRUE.* When the condition evaluates to *FALSE* the associated rule is deactivated (until it again becomes *TRUE*). This form also can occur only as a *<policy top element>.*

In either form the predicates used as a <*condition*> must be declared in a <*conditions declaration*>. This declaration should occur in the position of a top-level (not nested in a conditional) <*element*>, and has the form:

conditions([<predicate name>(<predicate args>), ...]))

<predicate args> indicate the number and type of arguments, and may be a list or a single item. Only one <*conditions declaration*> is permitted per policy but it may appear anywhere in the list of policy elements.

More information about conditional policy rules, permissible constructs in a <condition>, and the supporting structures and functions for the evaluation of conditions and their linkage to Context, as provided by the Context Monitoring and Extraction (CME) module, is contained in the Final Specification document.

The initial character of all identifiers must be a lower-case letter or the identifier must be quoted with single quotes, e.g. *smith* or *'Smith'* (identifiers are case sensitive so these examples are distinct). Quoting of an identifier that starts with a lower-case letter is optional, e.g. *smith* and *'smith'* are not distinct.

Additionally:

< *inh* > can be **yes** or **no**.

< *host name*> contains the name of the host where the corresponding file system object resides.

< *path name*> is the complete path name of the corresponding file system object.

An example of a simple conditional policy is shown in Figure 3.

```
policy('CondPolicy1','Conditional Access', [
      conditions([current_day_is_one_of(list)]),
      user('u1'),
      user('u2'),
```

```
        user_attribute('GroupA'),
        user_attribute('GroupB'),
        user_attribute('Division'),
        object('o1'),
        object('o2'),
        object('o3'),
        object_attribute('ProjectA'),
        object_attribute('ProjectB'),
        object_attribute('GrB-Secret'),
        object_attribute('Projects'),
        policy_class('Conditional Access'),
        connector('PM'),
        assign('u1','GroupA'),
        assign('u2','GroupB'),
        assign('GroupA','Division'),
        assign('GroupB','Division'),
        assign('o1','ProjectA'),
        assign('o2','ProjectB'),
        assign('o3','GrB-Secret'),
        assign('ProjectA','Projects'),
        assign('ProjectB','Projects'),
        assign('Division','Conditional Access'),
        assign('Projects','Conditional Access'),
        assign('GrB-Secret','Conditional Access'),
        assign('Conditional Access','PM'),
        associate('GroupA',[w],'ProjectA'),
        associate('GroupB',[w],'ProjectB'),
        cond( current_day_is_one_of(['Monday','Tuesday','Wednesday','Thursday','Friday']),
              associate('GroupB',[r,w],'GrB-Secret') ),
        associate('Division',[r],'Projects')
]).
```

Figure 3 Conditional policy example

In the example, the conditional rule specifies an association that is only to be effective on weekdays, with the result that 'GrB-Secret' data is only accessible to users in 'GroupB' at those times.

During the processing of an access query by the PDP, the evaluation of conditional rules in the declarative policy language may occur. Currently the policy elements that may appear in a conditional rule are limited to user, object, assign (of a user to a user_attribute, or an object to an object_attribute), and associate.

The condition consists of a Condition Predicate or a Built-in Relation. The evaluation of both condition predicates and built-in relations may depend on the values of Condition Variables occurring in the predicate instances and definitions. To facilitate development and testing of policies with conditional rules, a condition may also be the Boolean constant true or false. A few condition predicates may be predefined by the NGAC implementation, but the ability to define application-specific condition predicates is a useful feature. Currently, the predefined condition predicates are: **is_True**(x),

is_False(x), **unix** and **windows**. The predicates **is_True** and **is_False** test their single argument for the respective Boolean values. The predicates **unix** and **windows** evaluate to **true** if NGAC is running on the corresponding operating system, **false** otherwise. Over time other generally useful condition predicates may be added.

A built-in relation is currently defined as one of the binary relations in Figure 4.

Figure 4 Built-in relations available in DPL conditional rules

is_equal_to(X, Y)
is_unequal_to(X, Y)
is_member_of(Element, List)
is_subset_of(List1, List2)
is_less_than(X, Y)
is_greater_than(X, Y)
is_less_than_or_equal_to(X, Y)
is_greater_than_or_equal_to(X, Y)

Arguments to condition predicates or built-in relations may be a boolean (true/false), number, name, a list constant, or a variable with one of these types of value, as is consistent with the usage of the argument in the predicate. Variables used in the occurrence of condition predicates in a conditional rule are referred to as Condition Variables. A few condition variables may be predefined by the NGAC implementation, but the ability to define application-specific condition variables is essential to achieve flexible context sensitivity. Currently, the only predefined condition variables are: **zero** (having the value 0), **local_time** (a string having year, month, day, hour, minute and second, but may not be useful for comparisons), **local_day** (the name of a day of the week), **local_hour** (as a number), and **local_minute** (as a number).

The concept of a condition variable is independent of the source of its value and is a generalization intended to support context sensitivity, but may provide other environmental values not available from the Context Monitoring and Extraction (CME) module. For context sensitivity a condition variable must be mapped to a Context Variable the value of which is capable of being retrieved from the CME. The value for a condition variable that is not mapped to a context variable must be provided by another part of the system through a registered local_condition_variable_value reference.

A declaration of the needed context variables and a mapping from the condition variables to the corresponding context variables is provided in a file named “context.pl”. The file is consulted, if the file exists, for any such definitions that it may contain. This is done at CPA initialization time, and

the defined context variables are retrieved from the CME and their values placed in the Context Variable Cache. During this process, CPA can subscribe to be notified upon changes in the values of these context variables by the CME by providing call-back information about how to notify the CPA upon context change. Those context variables requested by the CPA that cannot be retrieved from the CME are silently ignored.

An example of the context.pl file is shown in Figure 5.

Figure 5 Context-sensitive Security Configuration file example

```
context_variables([ % variables obtained from the context system
   contextVar1 : number,
   contextVar2: name,
   holiday: boolean,
   lockdown: boolean ]).
condition_context_variable_map(condVar1, contextVar1).
condition_context_variable_map(condVar2, contextVar2).
condition_context_variable_map(holiday, holiday).
condition_context_variable_map(lockdown, lockdown).
```

An example of the conditions.pl file is shown in Figure 6.

Figure 6 Policy Conditions Configuration file example

```
% CONDITION VARIABLE DECLARATIONS
%   condition_variable( VariableName : VariableType )
%   VariableType is one of: list, boolean, number, name
condition_variable(local_day : name).
condition_variable(lockdown : boolean).

% CONDITION PREDICATE DECLARATIONS
%    condition_predicate(PredicateName,PredicateArgs)
%    PredicateArgs is a list of Types
%   Each Type is one of: list, boolean, number, name, any

condition_predicate(current_day_is_one_of, [list]).
condition_predicate(not_lockdown, [ ]).

% CONDITION PREDICATE DEFINITIONS

current_day_is_one_of(SetOfDays) :-
   condition_variable_value(local_day, Today),
   memberchk(Today,SetOfDays).

not_lockdown :-
```

```
condition_variable_value(lockdown,L), is_False(L).
```

4. EVENT-RESPONSE LANGUAGE

The Event-Response Language used to express an Event-Response package that may be loaded into the ERA module of the Event Processing Point component for on-line use, or into the 'ngac' policy tool for off-line testing (there may be some limitations on the ability of the policy tool implementation to mimic a standalone Policy Server and EPP instantiation).

The ERL's definition and implementation are intended to be easily extensible in both the Event pattern aspect and the Response action aspect. That is, the implementation of Event pattern specification and matching may be separate and distinct from the Response action execution. More powerful Event pattern specification and matching may be specified and implemented in the future without changing the existing Response action specification and implementation, or vice versa. The organization of the Response action dispatcher should permit easy addition of new actions.

The Event-Response Language (ERL) is read and interpreted by the Policy Tool, permitting policies in this language to be tested. It can also be loaded into the EPP for production use.

An event-response package specification is of the form:

er_package(<E-R package name>, <E-R rules>).

where,

<E-R rules> is a list [*< E-R rule >, ... , < E-R rule >*]

where each *<E-R rule >* is:

er (< event pattern > , < response >)

an *<event pattern >* is:

ev_pat(<user spec>, <pc spec>, <op spec> , <obj spec>)

a *<user spec >* is: *<user spec 1>* or a list [*< user spec 1>, ... , < user spec 1>*]

where *< user spec 1>* is,

user(<user identifier>) || user_attribute(<user attribute ID>) || user(any) ||

session(<session identifier>) || process(<process ID>) ||

user(<user identifier>) || user_attribute(<user attribute identifier>) ||

a <*pc spec*> is,

policy_class(<policy class identifier>)

an <*op spec*> is,

operation(<operation identifier>) || <operation set identifier>

a <*obj spec*> is,

object(<object identifier>) || object(any)

a <*response*> is a list,

[*< admin command >, ... , < admin command >*]

an *<admin command>* is among [3] the Policy Administration Interface commands, formatted in the form: *command(arg1, arg2, ..., argN)*. There is an additional command, *log(message)*, where *message* is a single-quoted string, that adds the message to the EPP's execution log.

5. ENHANCED 'NGAC' POLICY TOOL

The 'ngac' policy tool for doing standalone policy development and testing is extended for policy composition and with the ability to start the security server. The policy tool provides the ability to work with a policy as it is being created or modified to test its interpretation by the access calculating algorithms.

5.1 POLICY TOOL INTERACTIVE COMMANDS

The 'ngac' Policy Tool is a command driven application. After starting 'ngac' it offers the prompt "ngac>". There are a set of basic commands available in the normal mode (admin) and an extended set of commands for use by a developer in development mode (advanced). Entering the command "help" will list the available commands in the current mode. Only the most commonly needed commands are introduced here.

- `access(` <policy name>`,` <permission triple>`).`

[3] The permitted commands ERL admin commands are a subset of the Policy Administration Interface.

Check whether a permission triple is a derived privilege of the policy.

- `activate_erp(` <er package name> `).`
  Activate an event-response package already loaded in the EPP.

- `admin.`
  Switch to admin (normal) user mode.

- `advanced.`
  Switch to advanced user mode.

- `aoa(` <user> `).`
  Show the user accessible object attributes of the current policy.

- `combine(` <policy name 1>`,` <policy name 2>`,` <combined policy name> `).`
  Combine two policies to form a new combined policy with the given name.

- `current_erp.`
  Print the name of the current event-response package.

- `deactivate_erp(` <er package name> `).`
  Deactivate without unloading an event-response package already loaded in the EPP.

- `echo(` <string > `).`
  Print the argument string, useful in command procedures.

- `epp(`<port>`).`
  Start the Event Processing Point on the given port number.

- `epp(`<port>, <token>`).`
  Start the Event Processing Point on the given port number with <token> authenticator.

- `getpol.`
  Show the name of the current policy.

- `halt.`
  Exit the policy tool. (Will also terminate spawned server.)

- `help.`
  List the commands available in the current mode.

- `help(` <command name> `).`

Give a synopsis of the named command.

- `import_policy(` <policy file> `).`
  Import a declarative policy file and make it the current policy.

- `load_erf(` <erp file> `).`
  Load an event-response package from file into the EPP.

- `newpol(` <policy name> `).`
  Set the named policy to be the new current policy. Deprecated for `setpol`.

- `nl.`
  Print a newline, useful in command procedures.

- `policy_graph.`
  Display the current policy. Temporary files are created in the GRAPHS directory and removed at the end of the command execution. The GRAPHS directory is created if it does not exist. The rendered image is displayed on the console.

- `policy_graph(` <policy name> `).`
  Display the named policy. The specified name can be "current_policy". Temporary files are created in the GRAPHS directory and removed at the end of the command execution. The GRAPHS directory is created if it does not exist. The rendered image is displayed on the console.

- `policy_graph(` <policy name>`,` <file base name> `).`
  Generate the graph for the named policy and store the Dot language version in the file GRAPHS/<file base name>.dot and the rendered graph in the file GRAPHS/<file base name>.png. The GRAPHS directory is created if it does not exist. The rendered image is displayed on the console.

- `policy_spec.`
  Display the current policy.

- `policy_spec(` <policy name> `).`
  Display the named policy. The specified name can be "current_policy".

- `policy_spec(` <policy name>`,` <file base name>`,`
  `[silent]).`

Display the named policy and store in a the file POLICIES/<file base name>.pl . The optional third argument “silent” inhibits the console output of the policy.

- `proc(` <procedure name> [`, step`] `).`
  Run the named command procedure, optionally pausing after each command.

- `proc(` <procedure name> [`, verbose`] `).`
  Run the named command procedure, optionally verbose.

- `quit.`
  Terminate ngac command loop or script, but stay in Prolog top level.

- `regtest.`
  Run built-in regression tests.

- `script(` <file name> [`, step`] `).`
  Run the named command file, optionally pausing after each command.

- `script(` <file name> [`, verbose`] `).`
  Run the named command file, optionally verbose.

- `selftest.`
  Run built-in self tests.

- `server(` <port > `).`
  Start the Policy Server on the given port number.

- `server(` <port >`,` <admin token> `).`
  Start the Policy Server on the given port number, with given admin token.

- `server(` <port >`,` <admin token>`,` <epp token> `).`
  Start the Policy Server and EPP on the given port number, with given admin and epp tokens.

- `setpol(` <policy name> `).`
  Set the named policy to be the new current policy.

- `time( <ngac command> ).`
  Execute ngac command and report time stats.

- `time( <ngac command>, <reps> ).`
  Execute ngac command <reps> times and report total time stats.

- `unload_erp(` <er package name> `).`
  Unload an event-response package from the EPP.

- `version.`
  Display the current version number and version description.

- `versions.`
  Display past and current versions with descriptions.

There are, and may in the future be, advanced user commands for development and diagnostics.

5.2 POLICY SPECIFICATION AND GRAPH DISPLAY COMMANDS

The 'ngac' Policy Tool has two families of commands for displaying policy information. The policy specification of loaded policies may be sent to the console and/or to a file by the `policy_spec` commands.

A graphical rendering of loaded policies may be displayed on the console and optionally left in a file by the `policy_graph` commands. To generate the graphical display the 'ngac' Policy Tool converts the policy specification into a stylized-for-NGAC-policies graph description in the Dot language, which is subsequently rendered using the dot/graphviz tools. The graph display capability is experimental. Though an effort has been made to force the graphs to be laid out in the manner that has been established for NGAC policies, and our examples produce acceptable results, some complex policies may produce unexpected results.

5.3 TIMING COMMANDS

The 'ngac' Policy Tool has two commands for timing execution of other 'ngac' commands. The first, time(ngac_command) times the execution of a single command. The second, time(ngac_command, repetitions) executes the command for the number of times specified by the repetitions argument, and reports timing statistics. The second version turns off console output from the repeated execution of the command to eliminate the substantial timing impact of generating console output, leaving a result that is more representative of the processing time consumed by a server to do the equivalent work load.

5.4 COMMAND PROCEDURES AND SCRIPTS

There are predefined 'ngac'command procedures ("procs") that run the examples and can be used for testing and demonstrations. At the "ngac>" prompt a predefined procedure (e.g. named "myproc") can be run with the command `proc(myproc).` It can be run with verbose output with the command `proc(myproc,verbose).` It can be made to prompt and wait

for user instruction to proceed (empty line input) with the command `proc(myproc,step).`

It is instructive to read the file procs.pl that defines the predefined procedures. The procedures utilise the same commands available at the command prompt. The user may define additional procedures in the procs.pl file for subsequent execution as above.

A sequence of 'ngac' commands can also be stored in a file, in which case it is referred to as a *script*. Scripts may be run with a `script` command, analogous to the `proc` command, with the script file name substituted for the stored procedure name. `verbose` and `step` are valid options also for the execution of scripts.

5.5 'NGAC' POLICY TOOL IMPLEMENTATION

The implementation of the 'ngac' policy tool is comprised of the following Prolog modules:

- ngac.pl – top level module of 'ngac' policy tool; entry point and initialisation
- param.pl – global parameters (common with server and ngac tool)
- command.pl – command interpreter and definition of the 'ngac' commands
- common.pl – simple predicates that may be used anywhere
- pio.pl – input / output of various policy representations
- policies.pl – example policies used for built-in self-test
- test.pl – testing framework for self-test and regression tests
- procs.pl – stored built-in 'ngac' command procedures
- pmcmd.pl – PM RI command representations and conversions
- domains.pl – multi-domain policies
- dpl.pl – Declarative Policy Language (DPL)
- dpl_conditions.pl – conditional rules and condition variables for DPL
- pap.pl – the Policy Access Point (PAP)
- pdp.pl – the Policy Decision Point (PDP)

- test.pl – self-test infrastructure
- ui.pl – user interface primitives

6. 'NGAC-SERVER' LIGHTWEIGHT POLICY SERVER

Comprising the Policy Decision Point (PDP), the Policy Administration Point(PAP), and the Policy Information Point (PIP) of the NGAC functional architecture, the policy server implements a Policy Query Interface API to be queried by PEPs, and a Policy Administration Interface API to be used to incrementally change the policy the server is using to compute access queries.

The policy server may be initiated within the 'ngac' tool by issuing the command `server( <port> ).` or the command `server( <port>, <token> ).` at the tool's command prompt "ngac>". The preferred way to initiate the server in a production environment is by using the compiled executable, which makes the command line options available.

The 'ngac-server' currently provides two external interfaces, both implemented as RESTful APIs:

- Policy Query Interface – used by a Policy Enforcement Point to query whether a given access should be permitted under the current policy.
- Policy Administration Interface – used by a privileged "shell" or "portal" system program to load and unload policies, combine policies, select policies, etc.

Each of these interfaces will now be described in further detail. If the server was started with the `--jsonresp` option, the Returns will be JSON encoded. All JSON responses are of the form:

```
{
   "respStatus"    : <statusType>,
   "respMessage" : <statusDesc>,
   "respBody"      : <statusBody>
}
```

where <statusType> is "success" or "failure"; <statusDesc> and <statusBody> are specific to the API and depending on whether the respStatus is "success" or "failure".

6.1 POLICY QUERY INTERFACE (PQI)

A relatively simple interface, in the form of RESTful APIs, constitutes the Policy Query Interface.

This interface is used by a Policy Enforcement Point to determine whether a client-requested operation is supported by the associated user's permissions on the requested object under a particular policy, and if the operation is permitted where may the object be accessed through an appropriate Resource Access Point (RAP).

pqapi/access – test for access permission under current policy

Parameters

- user = <user identifier>
- ar = <access right>
- object = <object identifier>

Returns

- "permit" or "deny" based on the current policy
- "no current policy" if the server does not have a current policy set

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" : "grant" | "deny",
        "respBody" :  "<(user,ar,object) access triple>"
}
```

Effects

- none
- "grant" and "deny" are both "success" responses

pqapi/accessm – multiple access permission queries under current policy

Parameters

- access_queries = <query list> a list [(u,r,o), …] of access query triples (including empty list)

Returns

- a list ["grant" | "deny" | "malformed query", …] of the same length as the input parameter list corresponding to each access query triple in the <query list> based on the current policy
- "no current policy" if the server does not have a current policy set

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" :  "<query list>" same as the input parameter
        "respBody" : <result list>  a list ["grant" | "deny" | "malformed
        query", …] of the same length as the input parameter list
}
```

Effects

- none
- any <result list> (including empty list or list having a "malformed query" for any individual query) still has a "success" outcome.

pqapi/getobjectinfo – get object metadata

Parameters

- object = <object identifier>

Returns

- "object=<obj id>,oclass=<obj class>,inh=<t/f>,host=<host>, path=<path>,basetype=<btype>,basename=bname>"

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" : "objectinfo",
        "respBody" : "<object information structure>"
}
```

Effects

- none

An active session identifier may be used as an alternative to a user identifier in an access query made to the Policy Query Interface.

6.2 POLICY ADMINISTRATION INTERFACE (PAI)

Policy Administration is provided as a separate interface. Policy administration may still be done through the policy tool's command line interface, but it is best done through the server's RESTful Policy Administration API.

The enhanced server offers the following APIs as the Policy Administration Interface. A "failure" response is typically preceded by a string indicating the reason for the failure.

All of the APIs of the Policy Administration Interface have a ***token*** parameter[4] that acts as a key to use the interface. See the later discussion about protection of the PAI.

Policy Information/Manipulation

paapi/getpol – get current policy being used for policy queries

Parameters

- token = <admin token>

Returns

- <policy identifier> or "failure"

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" : "current policy",
```

[4] The default value of the admin token, established in the param.pl file, is 'admin_token'.

"respBody" : “<policy identifier>”
}

Effects

- none

paapi/setpol – set current policy to be used for policy queries

Parameters

- policy = <policy identifier>
- token = <admin token>

Returns

- “success” or “failure”
- “unknown policy” if the named policy is not known to the server

Returns (JSON)

{
"respStatus" : ”success”,
"respMessage" : "policy set”,
"respBody" : “<policy identifier>”
}

Effects

- sets the server’s current policy to the named policy
- distinguished policy names have special effects: “all” – the composition of all subsequently loaded policies to be applied; “grant” – all queries to return “grant”; “deny” – all queries to return “deny”

paapi/add – add an element to the current policy

Parameters

- policy = <policy identifier>
- policyelement = <policy element> only user, object, and assignment elements as defined in the declarative policy language; restriction: only user to user attribute and object to object attribute assignments may be added. Elements referred to by an assignment must be added before adding an assignment that refers to them.[5]
- token = <admin token>

Returns

- “success” or “failure” (if add constraints not met)

Returns (JSON)

{
"respStatus" : ”success”,
"respMessage" : "element added”,

[5] In a purely declarative sense this restriction would not be necessary. This applies also to the restriction on ***delete***. It is necessary only because at the time that the ***add*** is encountered the implementation performs a check to guarantee that the resulting policy will not have “loose ends”. A different implementation could perform a consistency check before a policy is used that has had ***add***/***delete*** operations performed since it was last checked.

"respBody" : “<policy element>”

}

Effects

- The named policy is augmented with the provided policy element

paapi/addm – add multiple elements to the current policy

Parameters

- token = <admin token>
- policy = <policy identifier>
- policyelements = [<policy element> , …] only user, object, assign and associate elements as defined in the declarative policy language; restriction: only user to user attribute and object to object attribute assignments may be added. Elements referred to by an assignment must be added before adding an assignment that refers to them.[6]

Returns

- “success” or “failure” (only for missing argument or token error)

Returns (JSON)

{

"respStatus" : ”success”,

"respMessage" : "elements added”,

"respBody" : “<policy elements>”

}

Effects

- The named policy is augmented with the provided policy elements.

Unlike ***paapi/add*** this call does not fail for the failure of an add of any of the individual elements. Note that this feature of ***paapi/addm*** can be used instead of ***paapi/add*** to issue an add that is immune to failure by passing a list consisting of just one policy element. The user is responsible for maintaining consistency of the policy.

paapi/delete – delete an element from the current policy

Parameters

- policy = <policy identifier>
- policyelement = <policy element> permits only user, object, and assignment elements as defined in the declarative policy language; restriction: only user-to-user-attribute and object-to-object-attribute assignments may be deleted. Assignments must be deleted before the elements to which they refer.

[6] In a purely declarative sense this restriction would not be necessary. This applies also to the restriction on ***delete***. It is necessary only because at the time that the ***add*** is encountered the implementation performs a check to guarantee that the resulting policy will not have “loose ends”. A different implementation could perform a consistency check before a policy is used that has had ***add***/***delete*** operations performed since it was last checked.

- token = <admin token>

Returns

- "success" or "failure" (if the element does not currently exist)

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" : "element deleted",
        "respBody" : "<policy element>"
}
```

Effects

- The specified policy element is deleted from the named policy

paapi/deletem – delete multiple elements from the current policy

Parameters

- token = <admin token>
- policy = <policy identifier>
- policyelements = [<policy element> , …] only user, object, assign and associate elements as defined in the declarative policy language; restriction: only user-to-user-attribute and object-to-object-attribute assignments may be deleted. Assignments must be deleted before the elements to which they refer.

Returns

- "success" or "failure"

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" : "elements deleted",
        "respBody" : "<policy elements>"
}
```

Effects

- The specified policy elements are deleted from the named policy.

Unlike ***paapi/delete*** this call does not fail for the failure of a delete of any of the individual elements. Note that this feature of ***paapi/deletem*** can be used instead of ***paapi/delete*** to issue a delete that is immune to failure by passing a list consisting of just one policy element. The user is responsible for maintaining consistency of the policy.

paapi/combinepol – combine policies to form new policy

Parameters

- policy1 = <first policy identifier>
- policy2 = <second policy identifier>
- combined = <combined policy identifier>
- token = <admin token>

Returns

- "success" or "failure"

- “error combining policies” if the combine operation fails for any reason

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "policies combined”,
        "respBody" : “<combined policy identifier>”
}
```

Effects

- the new combined policy is stored in the server

paapi/load – load a policy file into the server

Parameters

- policyfile = <policy file name>
- token = <admin token>

Returns

- “success” or “failure”

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "policy loaded”,
        "respBody" : “<policy identifier>”
}
```

Effects

- stores the loaded policy in the server
- does NOT set the server’s current policy to the loaded policy

paapi/loadi – load immediate policy spec into the server

Parameters

- policyspec = <policy specification>
- token = <admin token>

Returns

- “success” or “failure”

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "policy loaded immediate”,
        "respBody" : “<policy identifier>”
}
```

Effects

- stores the specified policy in the server
- does NOT set the server’s current policy to the loaded policy

paapi/unload – unload a policy from the server

Parameters

- policy = <policy identifier>

- token = <admin token>

Returns

- “success” or “failure”
- “unknown policy” if the named policy is not known to the server

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "policy unloaded”,
        "respBody" : “<policy identifier>”
}
```

Effects

- the named policy is unloaded from the server
- sets the server’s current policy to “none” if the unloaded policy is the current policy

paapi/readpol – read server policy

Parameters

- policy = <policy identifier> (optional, current is default)
- token = <admin token>

Returns

- <policy specification> of named (or current) policy, or “failure”
- “unknown policy” if the named policy is not known to the server

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "read policy”,
        "respBody" : “<policy specification>”
}
```

Effects

- no internal effects on server

Sessions in the Policy Server

An active session identifier may be used as an alternative to a user identifier in an access query made to the Policy Query Interface.

paapi/initsession – initiate a session for user on the server

Parameters

- session = <session identifier>
- user = <user identifier>
- token = <admin token>

Returns

- “success” or “failure”
- “session already registered” if already known to the server

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "session initialized”,
```

"respBody" : “<session identifier>”
}

Effects

- the new session/user binding is stored in the server

paapi/endsession – end a session on the server

Parameters

- session = <session identifier>
- token = <admin token>

Returns

- “success” or “failure”
- “session unknown” if not known to the server

Returns (JSON)

{
"respStatus" : ”success”,
"respMessage" : "session ended”,
"respBody" : “<session identifier>”
}

Effects

- the identified session/user binding is deleted from the server

6.3 GLOBAL POLICY QUERY INTERFACE (GPQI)

The Global Policy Query Interface supports access control of cross-domain operations. In a cloud-of-clouds each cloud (domain) may have its own local policy. The GPQI supports access checks where the user (subject) and the resource (object) are in different domains. There are additional policy rules that govern communication between the domains and the linking of the local policies through *external attributes*.

gpqapi/access – test for access permission under global+local policies

Parameters

- src = <user identifier>
- op = <operation access right>
- dst = <object identifier>

Returns

- “grant” or “deny” based on the current local and policies
- “no current local policy” if the server does not have a local policy set
- “no current global policy” if the server does not have a global policy set

Returns (JSON)

{
"respStatus" : ”success”,
"respMessage" : "grant" | “deny”,
"respBody" : “<(src,op,dst) access triple>”
}

Effects

- none
- “grant” and “deny” are both “success” responses

gpqapi/ggetinfo – get global object metadata

Parameters

- object = <object identifier>
- domain = <object’s policy domain>

Returns

- “object=<obj id>,oclass=<obj class>,inh=<t/f>,host=<host>, path=<path>,basetype=<btype>,basename=bname>”

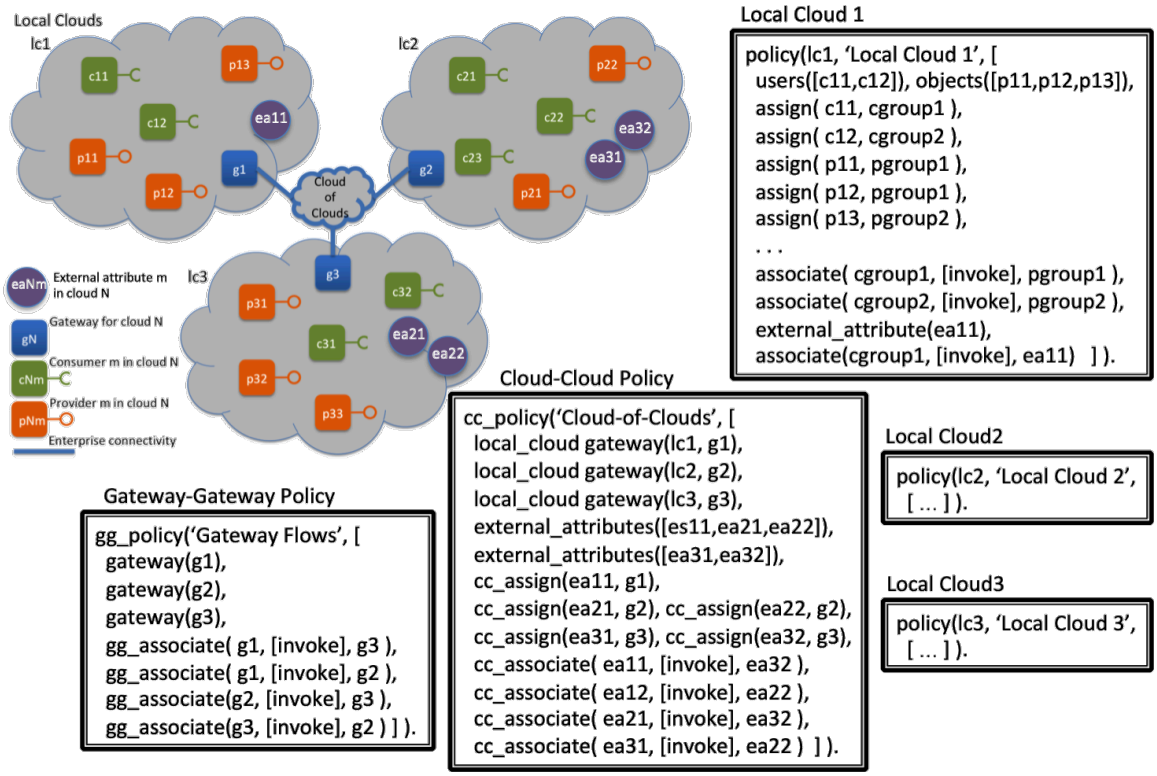
Returns (JSON)

```
{
        "respStatus" : ”failure”,
        "respMessage" : "ggetinfo unimplemented”,
        "respBody" :  “”
}
```

Effects

- none
- *functionality of this API is not yet implemented*

An example of the required policies is shown in the following figure.



6.4 GLOBAL POLICY ADMINISTRATION INTERFACE (GPAI)

Global Policy Administration is provided as a separate interface. Global policy administration may be done through the policy tool's command line interface, but it is best done through the server's RESTful Global Policy Administration API.

All of the APIs of the Policy Administration Interface have a ***token*** parameter[7] that acts as a key to use the interface. A "failure" response is typically preceded by a string indicating the reason for the failure.

Global Policy Information/Manipulation

gpaapi/getgpol – get current policy being used for global policy queries

Parameters

- token = <admin token>

Returns

- <global policy identifier> or "failure"

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" : "current global policy",
```

[7] The default value of the admin token, established in the param.pl file, is 'admin_token'.

"respBody" : “<global policy identifier>”
}

Effects

- none

gpaapi/setgpol – set current policy to be used for global policy queries

Parameters

- policy = <global policy identifier>
- token = <admin token>

Returns

- “success” or “failure”
- “unknown policy” if the named policy is not known to the server

Returns (JSON)

{
"respStatus" : ”success”,
"respMessage" : "global policy set”,
"respBody" : “<global policy identifier>”
}

Effects

- sets the server’s current global policy to the named policy

6.5 POLICY SERVER COMMAND LINE OPTIONS

When a compiled version of the policy tool or the policy server is started from the command line, several command line options are recognized.

- `--token`, `-t` <admintoken> use the token to authenticate requests to the paapi (formerly `--admin` or `-a`)
- `--deny`, `-d` respond to all access requests with `deny`, sets the current policy to `deny`, which may subsequently be changed by a `setpol` Policy Administration API call
- `--grant, --permit`, `-g` respond to all access requests with `grant`, sets the current policy to `grant`, which may subsequently be changed by a `setpol` Policy Administration API call
- `--epp`, `-e` run EPP in the Policy Server
- `--import`, `--load, --policy, -i, -l` <policyfile> import/load the policy file on startup
- `--port`, `--portnumber, --pqport, -p` <portnumber> server should listen on specified port number (default in param file)
- `--selftest`, `-s` run self tests on startup

- `--verbose`, `-v` show all messages
- `--jsonresp`, `-j` encode responses in JSON
- `--crosscpp`, `-c` URL of Cross-CPP system (default in param file)

6.6 DYNAMIC POLICY CHANGE

The Policy Server supports *dynamic total policy change*: the ability to load new policies, to form new policies composed of already loaded policies, and to select from among the loaded or composed policies that policy which is to serve as the policy used to make policy decisions. A policy selection remains in effect until a subsequent policy selection. The server retains all of the loaded and composed policies for the duration of its execution. In addition, the current implementation of the 'ngac-server' offers *limited dynamic selective policy change* after a policy is loaded or formed by combining policies. The ***add*** and ***delete*** APIs provide this capability. Details of the limitations are provided in the description of the APIs.

The current implementation of the PIP is ephemeral. There is no persistence of the policy database except in the original policy file(s) used to initialize the server and the sequence of commands issued to the server to modify policies after loading of policy files. To recreate a modified policy in a new server instance the original policy must be loaded followed by the same sequence of modifications issued to the server.

6.7 POLICY COMPOSITION

The policy server supports two forms of policy composition. The first is achieved with the ***comebinepol*** API. It forms the composition of policies as described in the NGAC literature and examples.

The ***'all'*** policy composition is a distinct form of policy composition. When the policy servers current policy is set to 'all' through the ***setpol*** API, all currently loaded policies are automatically combined for every ***access*** request. The manner in which the polices are combined is as follows:

- Every policy is first qualified to participate in computing the verdict of an ***access*** request. There are several subtle variations possible for qualification, and which to use is a parameter of the system. With the current setting of this parameter in the param module (all_composition = p_uo) to qualify a policy must be defined to have explicit jurisdiction over both the user and the object specified in the ***access*** request. There must be at least one qualifying policy.
- All qualified policies are queried with the triple (user, access right, object) specified in the ***access*** request. If any qualified policy returns 'deny' then the ***access*** request returns 'deny'.

Sets of policies to be combined according to the 'all' policy composition should be designed with the foregoing runtime semantics taken into consideration. The selection of the p_uo variant is currently a non-modifiable system parameter. It is being considered whether to permit the selection of the variant of the ***all_composition*** parameter to be specified when the 'all' composition mode is activated in the server through the ***setpol*** call.

6.8 PROTECTING THE POLICY ADMINISTRATION INTERFACE

The policy administration functions should not be made available to the normal object PEPs. Rather the Policy Administration API should be accessible only to an administratively authorised user through the policy administration tool or a process with the same authorisation, and some functions such as ***setpol***/***getpol*** should be accessible only to the "shell" program that executes the NGAC client application. In this way, the "shell" that controls execution of the application would also determine the user/session and policy under which the application should execute.

These protections may be achieved by appropriate use of the host operating system features, if such features are available. For example, on a Unix-like system, domain-specific trusted "shell" programs can be ***setuid*** to the owner of the domain, with the associated privileges passed along over a fork call and revoked before the child process performs an exec of an untrusted application program.

The admin token should be generated by the top-level process and passed in the ***token*** option when it starts the Policy Server. It or another trusted process that it spawns, to which it passes the token, can use the token to perform policy administration calls to the Server.

If the Policy Server is started without the ***token*** option it will use the default admin token defined in the param module in param.pl. The default is 'admin_token'. This default can be used in a benign environment or for development and testing. Note however that in a production environment where the Policy Administration Interface is not protected an untrusted process would be able to manipulate the policy being used by the Server.

6.9 AUDITING

The 'ngac-server' generates an audit log of audit records based on the current audit configuration. Auditing may be turned off or audit records may be sent to a log file of the standard error stream, based on the setting of the audit_logging parameter ('off', 'file' or 'on' respectively). Generated audit records are based on the current audit_selection parameter, which may be set to a subset of the auditable_events list enumerated in the file audit.pl. Currently, this setting is done automatically during initialization of the audit module.

6.10 'NGAC-SERVER' POLICY SERVER IMPLEMENTATION

The implementation of the 'ngac-server' lightweight server is comprised of the following Prolog modules:

- server.pl – HTTP server initiation.
- pqapi.pl – the policy query API.
- paapi.pl – the policy admin API.
- sessions.pl – registration of session identifiers and associated users to enable sessions identifiers to be used in place of the user in an ***access*** request for the life of the session.
- audit.pl – the 'ngac' audit module. (n_audit in v0.3.4+)
- domains.pl – multi-domain policies
- dpl.pl – Declarative Policy Language (DPL)
- dpl_conditions.pl – conditional rules and condition variables for DPL
- jsonresp.pl – JSON responses
- pap.pl – the Policy Access Point (PAP)
- pdp.pl – the Policy Decision Point (PDP)
- param.pl – system parameters (common with server and ngac tool)

7. 'EPP' EVENT PROCESSING POINT

Comprising the Policy Decision Point (PDP), the Policy Administration Point(PAP), and the Policy Information Point (PIP) of the NGAC functional architecture, the policy server implements a Policy Query Interface API to be queried by PEPs, and a Policy Administration Interface API to be used to incrementally change the policy the server is using to compute access queries.

The policy server may be initiated within the 'ngac' tool by issuing the command `server( <port> ).` or the command `server( <port>, <token> ).` at the tool's command prompt "ngac>". The preferred way to initiate the server in a production environment is by using the compiled executable, which makes the command line options available.

The 'epp' currently provides an interface implemented as a RESTful API:

The APIs will now be described in further detail. If the epp was started with the `--jsonresp` option, the Returns will be JSON encoded. All JSON responses are of the form:

```
{
   "respStatus"    : <statusType>,
   "respMessage" : <statusDesc>,
   "respBody"      : <statusBody>
}
```

where <statusType> is "success" or "failure"; <statusDesc> and <statusBody> are specific to the API and depending on whether the respStatus is "success" or "failure".

7.1 EPP COMMAND LINE OPTIONS

When a compiled version of the event processing point is started from the command line, several command line options are recognized.

- `--token`, `-t` <epptoken> use the token to authenticate requests to the EPP
- `--erp`, `--load, -e, -l` <erpfile> load the ER package file on startup
- `--context, -x` <context file> identify the context definition file
- `--conditions, -c` <conditions file> identify the conditions file

- `--port`, `-p` <portnumber> server should listen on specified port number
- `--selftest`, `-s` run self tests on startup
- `--verbose`, `-v` show all messages
- `--jsonresp`, `-j` encode responses in JSON

7.2 EVENT PROCESSING POINT INTERFACE (EPP)

The EPP provides a RESTful API for administration and event reporting.

In the legacy response format a "failure" response is typically preceded by a string indicating the reason for the failure.

All of the APIs of the EPP Interface have a ***token*** parameter[8] that acts as a key to use the interface. The default token is defined as epp_token in param.pl.

Policy Information/Manipulation

epp/load_erf – load an ER package from a file into the EPP
Parameters
- erpfile = <erp file name>
- token = <epp token>

Returns
- "success" or "failure"

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "ER package loaded from file”,
        "respBody" : “<(<erp file name>,<er package identifier>)>”
}
```

Effects
- stores the loaded ER package in the EPP
- activates the loaded ER package (subject to change)

epp/loadi_erp – load immediate ER package into the EPP
Parameters
- erp = <ER package specification>
- token = <epp token>

Returns
- "success" or "failure"

[8] The default value of the epp interface token, established in the param.pl file, is 'epp_token'.

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "ER package loaded immediate”,
        "respBody" : “<er package identifier>”
}
```

Effects

- stores the loaded ER package in the EPP
- activates the loaded ER package (subject to change)

epp/unload_erp – unload and ER package from the EPP

- erpname = <ER package name>
- token = <epp token>

Returns

- “success” or “failure”
- “unknown package” if the named ER package is not known to the EPP

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "ER package unloaded”,
        "respBody" : “<er package identifier>”
}
```

Effects

- the named ER package is deactivated and unloaded from the EPP
- sets the EPP’s current ER package to “none” if the unloaded erp is the current erp

epp/activate_erp – activate an ER package in the EPP

- erpname = <ER package name>
- token = <epp token>

Returns

- “success” or “failure”
- “unknown package” if the named ER package is not known to the EPP

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "ER package activated”,
        "respBody" : “<er package identifier>”
}
```

Effects

- the named ER package is made the current package in the EPP
- no change if the named ER package in not known

epp/deactivate_erp – deactivate an ER package in the EPP

- erpname = <ER package name>
- token = <epp token>

Returns

- “success” or “failure”
- “unknown package” if the named ER package is not known to the EPP

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "ER package deactivated”,
        "respBody" : “<er package identifier>”
}
```

Effects

- the named ER package, if active, is deactivated and the current package set to “none”
- no change if the named ER package in not currently activated

epp/current_erp – get name of the current active ER package

- token = <epp token>

Returns

- <ER package name> or “failure” (if there is currently no active package the name returned is ‘none’)

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "current ER package”,
        "respBody" : “<er package identifier>”
}
```

Effects

- none

epp/report_event – report an event to the EPP

- event = <event term>
- token = <epp token>

Returns

- “success” or “failure”

Returns (JSON)

```
{
        "respStatus" : ”success”,
        "respMessage" : "event reported”,
        "respBody" : “<event term>”
}
```

Effects

- The event term (a named event or event structure) is compared against event patterns, and triggers a response if an event pattern is matched.

The response may cause a specified sequence of administrative actions to be executed.

- no effect if the event does not cause an event pattern to be matched

epp/context_notify – notify EPP of context change

- context = [<variable name>:<variable value>, <variable name>:<variable value> , …] Variable names begin with a lower case character.
- token = <epp token>

Returns

- "success" or "failure"

Returns (JSON)

```
{
        "respStatus" : "success",
        "respMessage" : "context change notification accepted",
        "respBody" : "<context>"
}
```

Effects

- The context variable cache is updated to the values in context
- no change if the named variable are not already in the cache

7.3 'EPP' EVENT PROCESSING POINT IMPLEMENTATION

The implementation of the 'epp' is comprised of the following Prolog modules:

- epp.pl – HTTP EPP server initiation.
- eppapi.pl – the EPP's administration and event/context reporting APIs.
- epp_cpa.pl – context-dependent policy adapter.
- epp_era.pl – event response actuator.
- epp_pcc.pl – policy change constraints.
- erl.pl – the Event-Response Language (ERL)
- jsonresp.pl – JSON responses
- conditions.pl – definition of condition variables and predicates
- context.pl – definition of context variables and mappings
- param.pl – system parameters (common with server and ngac tool)

8. POLICY ENFORCEMENT POINT (PEP) AND RESOURCE ACCESS POINT (RAP) TEMPLATES

The template illustrates the construction of a PEP that queries the PDP and uses a RAP.

The PEP template exhibits the definition of a server for a RESTful Policy Enforcement Interface consisting of the APIs:

- peapi/getLastError – get the error code corresponding to the last error in the API
- peapi/getObject – get an entire object (including opening/closing)
- peapi/putObject – put an entire object (including opening/closing)
- peapi/openObject – open an object for incremental reading/writing
- peapi/readObject – read from an open object
- peapi/writeObject – write to an open object
- peapi/closeObject – close an open object

The RAP template should illustrate how a PEP may access a resource server through a RAP. The example included is a RAP for ordinary OS files, and illustrates file_open, file_close and file_read APIs.

9. INSTALLATION AND OPERATION

9.1 INTRODUCTION

The ‘ngac’ system is composed of two components, the ‘ngac’ Policy Tool and the ‘ngac-server’ Policy Server. The Policy Tool is used to test NGAC policies during their development. The Policy Server uses those policies to provide a runtime policy decision making service. These components share a common set of Prolog source modules and their separate executables are constructed with a simple shell script, ***mkngac***, which accompanies the sources. A primary objective of the ‘ngac’/’ngac-server’ development is to create a lightweight and highly portable access control framework that can be easily adapted to different situations and applications, that has a minimum of external dependencies, and that requires minimal resources to run. This objective has been achieved to a high degree in the current implementation.

9.2 PREREQUISITES

The ‘ngac’ Policy Tool and the ‘ngac-server’ Policy Server are implemented in the Prolog language and require the SWI-Prolog environment to run. This is the software’s sole external dependency apart from the operating system. The version of SWI-Prolog used for the current version is version 7.6.4 available from www.swi-prolog.org.

SWI-Prolog is available for several operating environments, including Microsoft Windows (64 bit) and (32 bit), MacOS X 10.6 and later on Intel, and several Linux versions including Ubuntu. It is also available in Docker containers and as a source distribution that one can build locally.

Our NGAC implementation uses *only* the libraries that come with the Prolog distribution. Furthermore, the functional architecture has been organized so as to place adaptation into the hands of application developers without requiring modification to the core implementation. This is in contrast to the reference implementations that have so many external dependencies (some obsolete) so as to be very cumbersome to work with and not very portable or adaptable.

The software is provided as a set of Prolog source files and/or as “executable” files that have the Prolog runtime environment already linked in. Prior to installing and building the software it is required that Prolog be installed. The exception to this requirement is if there is already a compiled version of ‘ngac’ and ‘ngac-server’ for the target platform, in which case all the dependencies are already linked into the executable.

9.3 INSTALLING AND RUNNING THE ‘NGAC’ POLICY TOOL

The ngac policy tool is implemented in Prolog and requires the SWI Prolog environment to run. The ngac tool can be provided as a set of Prolog source files and/or as an “executable” that has the Prolog runtime environment already bundled in. This executable is made by the shell script mkngac,

located with the source files that must be run in an environment that has SWI Prolog installed.

9.3.1 Install SWI-Prolog

SWI Prolog is available for several operating environments, including Mac, Windows, and Linux. See http://www.swi-prolog.org.

9.3.2 Install the 'ngac' source files and/or executable

The current version of the ngac tool consists of a directory tree including source files and example files. The distribution is provided as a zip file of this directory tree.

9.3.3 Initiate the 'ngac' policy tool

If a ready made executable 'ngac' has been provided it may be executed directly from a command shell prompt. If you do this skip down to "Now you should see …" below.

Otherwise, in the source directory ngac-server-2018-06 start SWI-Prolog from a command shell prompt using the name of the SWI-Prolog executable (usually 'swipl', 'swi-pl', or something similar, depending on how it was installed).

After printing a short banner SWI-Prolog will display its prompt "?- ".

At the Prolog prompt enter "[ngac]." (not the quotes)

Prolog will compile the code and print "true."

Execute the code by entering at the Prolog prompt "ngac."

Now you should see the 'ngac' prompt "ngac> '

9.3.4 Test the installed 'ngac' tool

The ngac tool has some self-tests built in. These should be run to ensure that everything is working correctly. Follow the instructions in the preceding section to run the ngac tool. Start it with the Prolog prompt command "ngac(self_test)." This will run some built-in self tests when it starts. To not run the self-tests simply start the tool with the Prolog prompt command "ngac."

The self tests can also be run by starting 'ngac' normally and entering at the 'ngac' prompt "selftest."

Procedures make up of 'ngac' commands may be predefined in the procs.pl file. Look at the ones there and try them by entering the ngac command

"proc(ProcName).", where ProcName is the name of one of the procedures defined in procs.pl.

9.3.5 Running the examples

There are several examples included with the sources of the ngac Policy Tool. These include examples described in documents and PowerPoint slide decks used to introduce the NGAC concepts.

There are predefined procedures ("procs") that run the examples. At the ngac> prompt a predefined procedure (e.g. named "myproc") can be run with the command `proc(myproc).` It can be run with verbose output with the command `proc(myproc,verbose).`

It is instructive to read the file procs.pl that defines the predefined procedures. The procedures consist of the same commands available at the command prompt. The user may define additional procedures in the procs.pl file for subsequent execution as above.

9.4 INSTALLING AND RUNNING THE 'NGAC-SERVER'

The ngac server is implemented in Prolog and requires the SWI-Prolog environment to run. The server can be provided as a set of Prolog source files and/or as an "executable" that has the Prolog runtime environment already bundled in. This executable is made by the shell script mkngac, located with the source files that must be run in an environment that has SWI Prolog installed.

9.4.1 Install SWI-Prolog

SWI Prolog is available for several operating environments, including Mac, Windows, and Linux. See http://www.swi-prolog.org.

9.4.2 Install the 'ngac' server source files and/or executable

The current version of the ngac server consists of a directory tree including source files and example files. The distribution is provided as a zip file of this directory tree.

9.4.3 Initiating the 'ngac-server'

The ngac server may started from the 'ngac' policy tool. In normal use the ngac server should be started with the compiled executable 'ngac-server'. This is preferable since it allows the command line options to be specified.

If you do want to start the server from the policy tool follow the instructions above to get 'ngac' running. After starting 'ngac' it offers the prompt "ngac>". There are a set of basic commands available in the normal mode (admin) and an extended set of commands for use by a developer in development mode (advanced). Entering the command "help" will list the

available commands in the current mode. If you want to load any policy files, do it now with the 'ngac' command "import(policy(PolicyFileName)).", where PolicyFileName is the name of a .pl file relative to the execution directory. You can also combine policies with the 'ngac' "compose" command. When you have the desired policies loaded and composed, start the server from the 'ngac' tool using the command "server(PortNumber).", where PortNumber is an unused TCP port. The server will be started and will be listening to that port for calls to its RESTful API. A server started in this way will expect the default admin token (the string "admin_token", without the quotes) in the policy administration API calls.

The 'ngac-server' can be run in the background from a startup script. To the command 'ngac-server' add any desired command line options and append a "&" to run the process in the background.

9.4.4 Test the installed 'ngac-server'

There are a number of shell scripts of curl commands included with the source in the TEST subdirectory. These scripts can be run to send a sequence of requests to the server to test for known correct answers. Basic tests are in `servercurltest.sh`. There is also a shell script of curl commands for testing policy composition (`serverCombinedtest.sh`). (Note: These scripts run illustrative tests, they do not run exhaustive tests.)

A top-level script `run-nn-tests.sh` runs all of the numbered test scripts. Expected results are contained in corresponding numbered files with, and without, the file name suffix "`-json`". The script takes a single optional argument "`-json`" which causes the results of the run to be compared against the numbered files with "`-json`" suffix. The ngac-server must be running in the appropriate mode (--jsonresp) to get JSON responses. (See server command line options.)

The tool can be easily extended in several ways.

- Commands can be added by modifying the `command` module to add a `syntax`, `semantics` (optional), `help`, and `do` clause for the new command. A `syntax` clause must be added for the command. This clause declares the command name and parameters, and what mode the command belongs to, admin or advanced. Admin commands are available in admin mode, but also accessible in the advanced mode but not vice versa.

- The self-test framework is implemented in the `test` module. Tests for specific new modules can be added in the `TEST` subdirectory. An example of a test definition file for the `spld` module is implemented in `TEST/spld_test.pl`.

- New predefined ‘ngac’ command procedures can be added to the `procs` module. A `proc` clause is added for each new procedure to be defined. There are examples in the `procs.pl` file.

- Condition variables and condition predicates can be defined in the `conditions.pl` file.

- Context variables can be defined in the `context.pl` file along with mappings of context variables to NGAC condition variables.

Global parameters are set in the `param` module. Settable parameters (those that can be changed from the ‘ngac’ command line with the `set` command) are itemized in a list `settable_params`. For example, the parameter audit_logging is a settable parameter. Adding new settable parameters requires the new parameter name to be added to the list of settable parameters and to the `dynamic` directive above it in a fashion similar to the other entries.

10. INTEGRATING NGAC WITH AN EXISTING SYSTEM

10.1 ADAPTING TO THE NGAC FUNCTIONAL ARCHITECTURE

Generally, when you take direct resource access code out of the application and replace it with PEP interface references the removed code will be represented in some form in the RAP. The PEP should be limited to marshaling the arguments to the PDP access call and determining what RAP to invoke and the needed parameters. Depending on the narrowness of the set of resources handled by the PEP (there can be multiple PEPs) the RAP call side of the PEP could be fairly simple. In fact, it is acceptable to combine the PEP and the RAP into a single execution unit (while keeping the functions separate) if the association of the PEP and RAP are 1-1. Since the RAP is now be acting for potentially multiple resource access references in one or more applications, it will be more general than any one individual reference. If there are multiple resource "locations" serviced (local or remote, for example) then it may be best to keep the PEP simpler by passing the location to the RAP and having the RAP access the proper location.

10.2 DEPLOYING THE NGAC COMPONENTS

The ngac server does not need to be running in any one particular place, but it should be used by all PEP/RAPs. It is not a strict rule but, generally, having the PEP close to the client app and having the RAP close to the resource makes sense, unless the PEP and RAP are combined, in which case a decision must be made where to deploy it.

10.3 CREATING A POLICY

1) identify the distinct objects to be protected (protected resources)
2) identify the set of possible operations on each object
3) identify the distinct users using identifiers that can be determined at runtime
4) for the users and for the objects determine a set of (binary) attributes
that are relevant to making policy decisions (that is attributes that a user
or an object either has, or does not have). Often it is convenient to create
attributes that make sense for the domain whether or not they correspond
to actual runtime entities.
5) make the appropriate assignments of users to user attributes,
user attributes to other user attributes, objects to object attributes, and
object attributes to other attributes.
6) make the graph connected by having the user side and the object side
both belong to the same policy class, and by having the policy class
belong to the connector 'PM' as in the diagram for the example policy.

Now, for web services I suggest to adapt the methodology slightly.
For this case I'm going to reuse some ideas from the example attached.
One should still identify the distinct objects (or resources) and the operations
permitted on them. Often there are multiple operations on the same object.
So now you must make a decision, for the policy you are going to create,
whether to have each Web API (URI) be a distinct *object*, or whether to

have the Web APIs be distinct *operations* on an underlying object.

Suppose you provided the contents of a file as a web service. There are multiple ways to package this. One way is to provide a separate read and write operations on the file object

fileAservice read
fileAservice write

which could also look like the APIs

fileAserviceRead
fileAserviceWrite

In the policy this could be:
policy(_, _. [
object(fileA),
object_attribute(served_file),
assign(fileA,served_file),
associate(ordinary_user,[read],served_file),
…]).

queries would look like access <u1,read,fileA>
where the operations are read and write

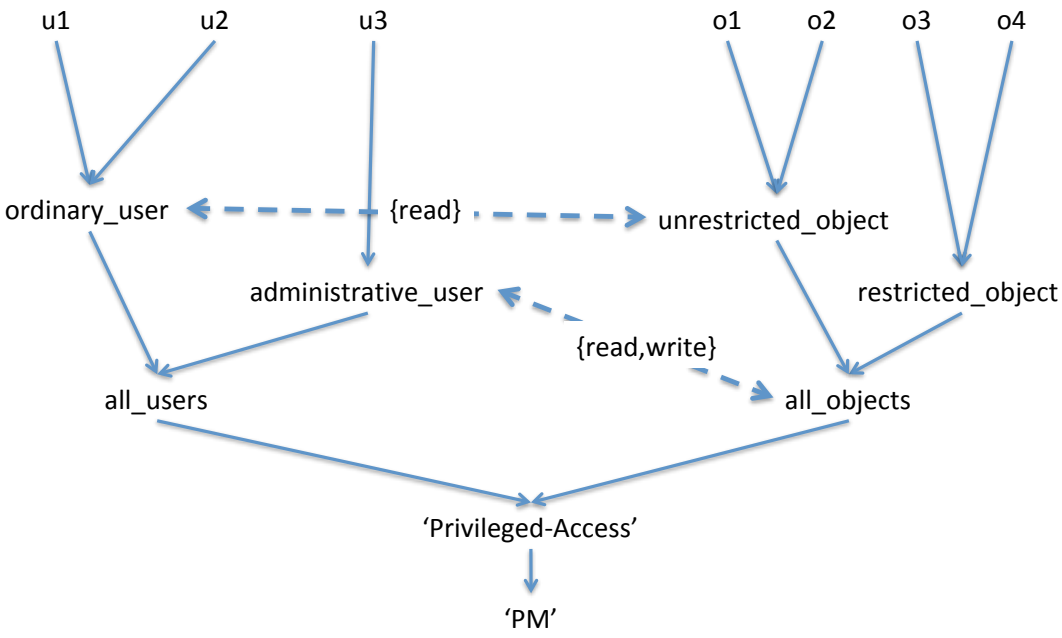
or:
policy(_, _. [
object(fileAread),
object(fileAwrite),
assign(fileAread,unrestricted_API),
assign(fileAwrite,restricted_API),
associate(ordinary_user,[call],unrestricted_API),
associate(administrative_user,[call],all_APIs),
…]).

queries would look like access <u1,call,fileAread>
where the operation is call

it all depends on how you want to organize the concepts in the policy and whether you want to think of every API (URI) as an independent resource (even if it operates on the same underlying object) or think of potentially multiple APIs providing different operations on the same underlying object.

The Policy Enforcement Point for a web service could be a proxy for the service that calls the PDP. It is essential that a user of the service can only access the service through the PEP proxy.

Example ‘Policy4’: ‘Privileged-Access’



Example ‘Policy4’: ‘Privileged-Access’

```
policy('Policy4','Privileged-Access', [

    user(u1),
    user(u2),
    user(u3),

    user_attribute(ordinary_user),
    user_attribute(administrative_user),
    user_attribute(all_users),

    object(o1),
    object(o2),
    object(o3),
    object(o4),

    object_attribute(unrestricted_object),
    object_attribute(restricted_object),
    object_attribute(all_objects),

    policy_class('Privileged-Access'),

    connector('PM'),

    assign(u1,ordinary_user),
    assign(u2,ordinary_user),
    assign(u3,administrative_user),

    assign(ordinary_user,all_users),
    assign(administrative_user,all_users),

    assign(o1,unrestricted_object),
    assign(o2,unrestricted_object),
    assign(o3,restricted_object),
    assign(o4,restricted_object),

    assign(unrestricted_object,all_objects),
    assign(restricted_object,all_objects),

    assign(all_users,'Privileged-Access'),
    assign(all_objects,'Privileged-Access'),

    assign('Privileged-Access','PM'),

    associate(ordinary_user,[read],unrestricted_object),
    associate(administrative_user,[read,write],all_objects)
]).
```


10.4 ENFORCING THE NGAC FUNCTIONAL ARCHITECTURE

The components of the NGAC functional architecture can only do their intended functions, and the architecture achieve its intended benefits, in the face of a hostile environment, if they can operate without malicious interference. That is, the functional architecture must be affirmatively *enforced*. Since the NGAC components run with the existing system as their “IT environment” it is necessary to embed the NGAC components within the environment in a way that achieves the two essential properties of a reference validation mechanism (aside from the obvious first one: correctness), that is, tamper-proof-ness and non-bypassability (“always invoked”). These properties cannot be achieved by the mechanism itself, but must be provided for the mechanism by its environment through a proper embedding and use of the native protection features of the environment. To accomplish this, particularly in the case of distributed systems with many kinds of protected resources, may not be a trivial matter.

We note that some deployments of NGAC are done with the intention of demonstrating the utility or benefits of a common attribute-based access control system such as NGAC within a particular application. In the case of such benign environments, it is the proof-of-concept of the utility of a unified access control system that is the goal, not absolute and complete robustness of the deployment in the demonstrator. As long as it is feasible, in principle,

to achieve the enforcement of the functional architecture, we argue that it may not be justified to expend the resources to achieve that enforcement in the deployment. We have found this to be the case in some of our projects in which the goal is to demonstrate the utility of fine-grained access control in new contexts where it can address a resource protection challenge that is unique to, or exacerbated by, the application concerned.

For the purpose of this discussion on the deployment of NGAC we assume the environment to be a general-purpose operating system or embedded operating system that provides basic protections, such as process integrity, process identity, file object integrity, and file access controls. For the sake of example we shall assume a Unix-like operating system or one providing similar features in the area of basic protections mentioned above.

Let us begin by outlining the requirements:

Specifically, and at a minimum, the PEP, RAP, and PDP/PAP/PIP should run as distinct processes that should be run with a reserved user identity (we'll call it user *ngac*).

The Policy Query Interface of the PDP and the Resource Access Interface of the RAP should be restricted to be callable only by PEPs.

The resources to be controlled by NGAC should be made to be accessible *exclusively* to the ngac user or otherwise limited to access only by the RAP through the corresponding resource server.