Dynamically Extensible Policy Server and Agent

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Background

- **The function of network node will be dynamically extensible.**
  - Software can be added/replaced by, e.g.,
    - Active packets
    - Java code injection
  - Hardware can be added/replaced by, e.g.,
    - Board addition/replacement
  - Both software and hardware functions can be added/replaced on-the-fly (while the node is running).
- **Thus, policies should be dynamically extensible.**
  - New classes of policies should be able to be added dynamically
    - if the network is controlled/managed by policies, and
    - if the network function may be added dynamically.

Problem

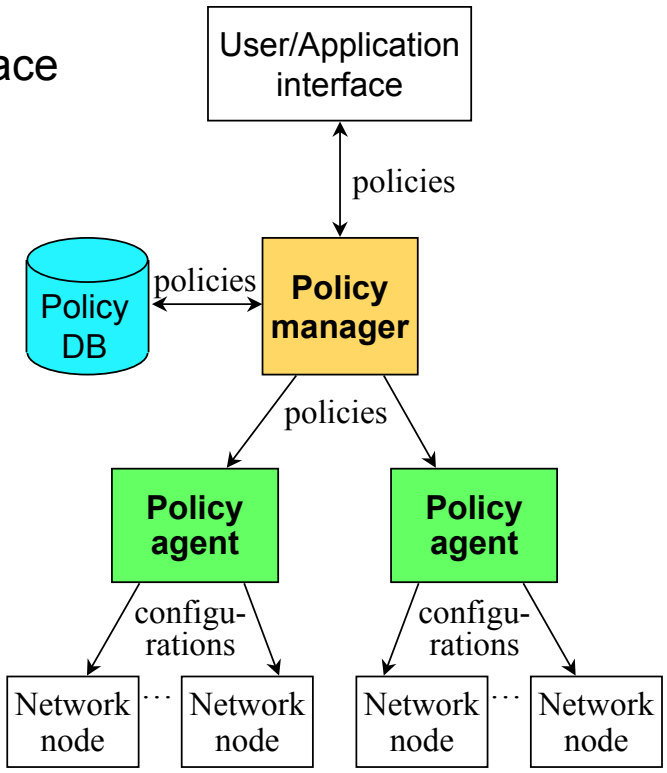
- **Conventional policy-based systems do not allow dynamic extension.**
  - E.g., in COPS-PR, policies are stored in statically-specified PIBs.
    - New classes of policies require new PIB specification.
    - If starndard-based, vendors must wait for PIB standardization.
    - No dynamic extension, even if non-standard PIB is used.

Solution

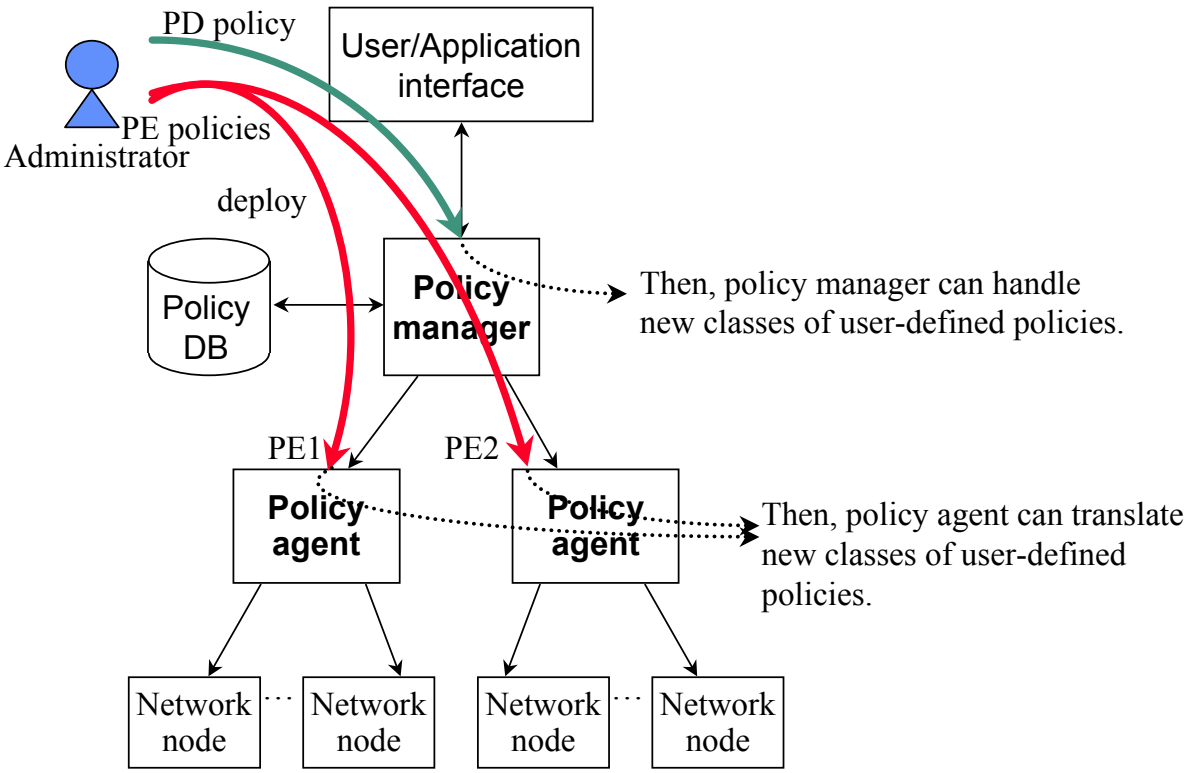
- **The policy-extension-by-policy (PXP) method has been developed.**
  - A new policy class is defined by predefined PD/PE policies in the PXP method.
    - A PD (policy definition) policy contains device-*in*dependent definitions of user-defined policy classes, and
    - A PE (policy embedding) policy contains device-dependent methods for translation of user-defined policies into device configurations.
    - PD/PE policies are meta policies.

An Architecture for the PXP Method

- **Software components**
  - User/Application interface
  - Policy manager (Policy server, PDP)
  - Policy database
  - Policy agents
- **Policy agents may be embedded in network nodes.**



Policy Deployment Process of the PXP Method

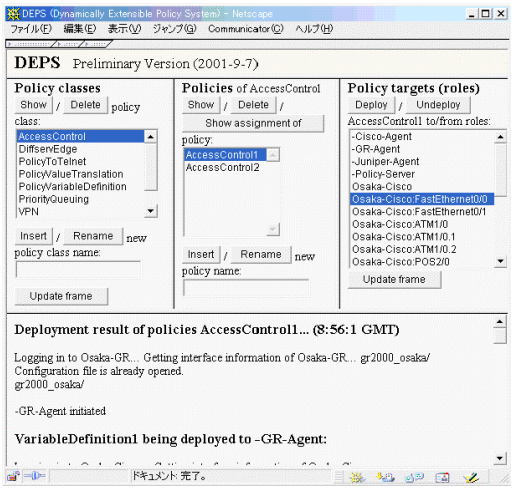


Basic Policy Information-model

- **A policy is a sequence of policy rules: P = {*r*1, *r*2, …, *rn*}.**
- **A policy rule consists of**
  - A list of conditions: *c*1, *c*2, …, *cm*
  - A list of actions: *a*1, *a*2, …, *al*
- **A condition / an action consists of a variable and a value: *variable* = *value*.**
- **A policy (instance) belongs to a policy class.**
  - Class examples: Diffserv-edge, Access-control.
  - All the rules in a policy must have the same type of functionality.
- **Example** (a Diffserv-edge policy rule)
  - if (source_address = 192.168.1.1, protocol = 'tcp') { DSCP = 46; }

Prototype Development

- **Three policy classes were predefined.**
  - PolicyToTelnet (an amalgame of PD & PE policies)
    - Most important
  - PolicyVariableDefinition (a PD policy)
  - PolicyValueTranslation (an amalgame of PD & PE policies)



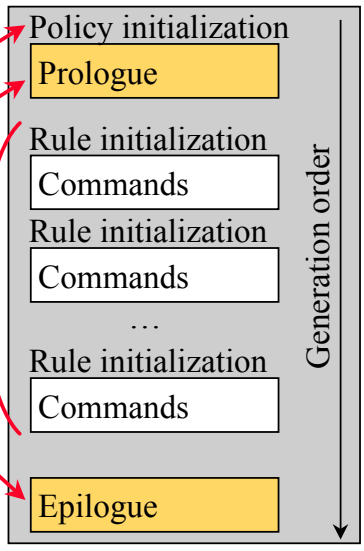
- **A PolicyToTelnet policy rule defines**
  - a user-defined policy class, and
  - the method of translating a policy of this class into CLI commands.

PE Policy

- **Two essential elements of PE policy rules are**
  - Command template
  - Template fillers
- **A command is generated from the pattern by filling the *unfinished* portions by using template fillers.**
- **Example**
  - Command template: `access-list %s permit %s %s %s.`
  - Fillers:
```
N + 1,
protocol || 'ip',
source_address || 'any',
destination_address || 'any'
```
    similar to printf in C
  - Command generation
    - Variable values: `N = 2, protocol = 'tcp',` `source_address = '192.168.1.1'`, and `destination_adress = ''`
    - `access-list 3 permit tcp 192.168.1.1 any`

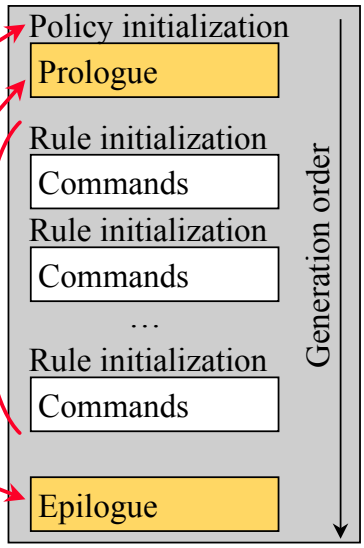
PolicyToTelnet Policy and Policy Deployment

```
# Condition part:
if (name = policy_class_name) {
  # Action part 1/3: Policy variable declarations
    condition_variables =
        {variable_name options, ...},
    action_variables =
        {variable_name options, ...},
  # Action part 2/3: Policy prologue/epilogue translators
    policy_initialization =
        {work_variable = initial_value, ...},
    policy_pre_deploy_commands =
        [[template, filler, filler, ...], ...],
    policy_post_deploy_commands =
        [[template, filler, filler, ...], ...],
    policy_pre_undeploy_commands =
        [[template, filler, filler, ...], ...],
    policy_post_undeploy_commands =
        [[template, filler, filler, ...], ...],
  # Action part 3/3: Policy rule translators
    rule_initialization =
        {work_variable = policy_bytecode_program, ...},
    rule_deploy_commands =
        [[template, filler, filler, ...], ...],
    rule_undeploy_commands =
        [[template, filler, filler, ...], ...] }
```



PolicyToTelnet Policy and Policy *Un*deployment

```
# Condition part:
if (name = policy_class_name) {
  # Action part 1/3: Policy variable declarations
    condition_variables =
        {variable_name options, ...},
    action_variables =
        {variable_name options, ...},
  # Action part 2/3: Policy prologue/epilogue translators
    policy_initialization =
        {work_variable = initial_value, ...},
    policy_pre_deploy_commands =
        [[template, filler, filler, ...], ...],
    policy_post_deploy_commands =
        [[template, filler, filler, ...], ...],
    policy_pre_undeploy_commands =
        [[template, filler, filler, ...], ...],
    policy_post_undeploy_commands =
        [[template, filler, filler, ...], ...],
  # Action part 3/3: Policy rule translators
    rule_initialization =
        {work_variable = policy_bytecode_program, ...},
    rule_deploy_commands =
        [[template, filler, filler, ...], ...],
    rule_undeploy_commands =
        [[template, filler, filler, ...], ...] }
```



Conclusion

- **By using the PXP method,**
  - Policies with new functionality can be added/replaced by using preexisting interfaces such as CLI, MIBs, PIBs, APIs, hardware tables.
  - Policy classes can be defined by users or applications much easier.