On Describing Combining Algorithms

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1 Introduction

I argue that policy- and rule-combining is a *function* ($\mathcal{C}$) that returns a value based on n inputs (representing the evaluation results from the child node) and it must be described as such.

The actual *algorithm* to compute such function and optimizing its efficiency so that it evaluates as few policy (rules) as possible, is a different topic that must be discussed separately. Currently, the specification mixes the two which I suggest must be avoided.

2 Values

The decision values are D, P, I_D, I_P, I_{PD}, N/A respectively for Deny, Permit, Indeterminate{P}, Indeterminate{D}, Indeterminate{PD}, and NotApplicable.

3 Un-ordered and Inductive

Un-ordered inductive functions are functions that are defined over a *set* of n values, $S = \{s_1, \cdots s_n\}$ and fit the following inductive definition:

$$\mathcal{C}(\mathcal{S}) = \begin{cases} F_{\mathcal{C}}(S) & \text{if } |S| = 2 \\ \mathcal{C}(\{s_1\} \cup \{\mathcal{C}(S \backslash \{s_1\})\}) & \text{if } |S| > 2 \end{cases}$$

in which F_c is a function that defines the combined result for all pairs of value.

3.1 Examples

3.1.1 Deny-Overrides

The *deny-overrides* function is un-ordered and inductive, and F_c is given as:

	D	P	I_D	I_P	I_{PD}	N/A
N/A	D	P	I_D	I_P	I_{PD}	N/A
I_{PD}	D	I_{PD}	I_{PD}	I_{PD}	I_{PD}	
I_P	D	I_P	I_{PD}	I_P		
I_D	D	I_{PD}	I_D			
P	D	P				
D	D					

3.1.2 Permit-Overrides

The *permit-overrides* function is un-ordered and inductive, and F_c is given as:

	D	P	I_D	I_P	I_{PD}	N/A
N/A	D	P	I_D	I_P	I_{PD}	N/A
I_{PD}	I_{PD}	P	I_{PD}	I_{PD}	I_{PD}	
I_P	I_{PD}	P	I_{PD}	I_P		
I_D	I_D	P	I_D			
P	P	P				
D	D					

3.1.3 Deny-Unless-Permit

The *deny-unless-permit* function is un-ordered and inductive, and F_c is given as:

	D	P	I_D	I_P	I_{PD}	N/A
N/A	D	P	D	D	D	D
I_{PD}	D	P	D	D	D	
I_P	D	P	D	D		
I_D	D	P	D			
P	P	P				
D	D					

3.1.4 Permit-Unless-Deny

The *permit-unless-deny* function is un-ordered and inductive, and F_c is given as:

	D	P	I_D	I_P	I_{PD}	N/A
N/A	D	P	P	P	P	P
I_{PD}	D	P	P	P	P	
I_P	D	P	P	P		
I_D	D	P	P			
P	D	P				
D	D					

4 Un-ordered and Non-Inductive

An un-ordered function may be non-inductive. For example, the combining function *deny-unless-permit-majority* (with majority defined as greater than or equal to $\lfloor \frac{n}{2} \rfloor$). This combining function is not inductive, since for example: $\mathcal{C}(\{P, D, I_{PD}\}) = D$ which is not equal to: $\mathcal{C}(\{\mathcal{C}(\{P\}), \mathcal{C}(\{D, I_{PD}\})\})$.

Currently, either of the standard combining functions nor the ones proposed in the profiles are of this type.

5 Ordered and Inductive

Ordered inductive functions are functions that are defined over a *vector* of n values, $V = \langle v_1, \cdots, v_2 \rangle$ and fit the following inductive definition[1]. Note that un-ordered combining functions are a special case of the ordered functions with an $F_{\mathcal{C}}$ which is symmetric with respect to its inputs:

$$\mathcal{C}(\mathcal{V}) = \begin{cases} F_{\mathcal{C}}(\langle v_1, v_2 \rangle) & \text{if } |V| = 2 \\ \mathcal{C}(\langle \mathcal{C}(\langle v_1, \cdots v_{n-1} \rangle), v_n \rangle) & \text{if } |V| > 2 \end{cases}$$

in which F_c is a function that defines the combined result for all pairs of value.

5.1 Examples

5.1.1 First-Applicable

The *first-applicable* function is ordered and inductive, and F_c is given as below, with columns representing the first element of the pair and rows representing the second:

	D	P	I_D	I_P	I_{PD}	N/A
N/A	D	P	I_D	I_P	I_{PD}	N/A
I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}
I_P	I_P	I_P	I_P	I_P	I_P	I_P
I_D	I_D	I_D	I_D	I_D	I_D	I_D
P	P	P	P	P	P	P
D	D	D	D	D	D	D

5.1.2 Only-One-Applicable

The *first-applicable* function is ordered and inductive, and F_c is given as below, with columns representing the first element of the pair and rows representing the second:

[1] Note that I only consider the left-to-right order (top-down order of appearance in the XML). Right-to-left orders can be defined similarly if needed, and if they matter.

	D	P	I_D	I_P	I_{PD}	N/A
N/A	D	P	I_D	I_P	I_{PD}	N/A
I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}
I_P	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_P
I_D	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_D
P	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	P
D	I_{PD}	I_{PD}	I_{PD}	I_{PD}	I_{PD}	D

6 Ordered and Non-Inductive

Some policies are ordered but not inductive. For example, the *on-permit-apply-second* function which is defined as follows:

$$\mathcal{C}(\mathcal{V}) = \begin{cases} F_{\mathcal{C}}(\langle v_1, v_2 \rangle) & \text{if } |V| = 2 \\ I_{PD} & \text{if } |V| \neq 2 \end{cases}$$

	D	P	I_D	I_P	I_{PD}	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A
I_{PD}	I_D	I_P	I_D	I_P	I_{PD}	N/A
I_P	I_D	I_P	I_D	I_P	I_{PD}	N/A
I_D	N/A	N/A	N/A	N/A	N/A	N/A
P	D	P	I_D	I_P	I_{PD}	N/A
D	N/A	N/A	N/A	N/A	N/A	N/A