# On The Semantic Significance of an Association and Particles

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## The Semantic Significance Vector

## Semantic Significance of a primitive semantic particle

Recall that the properties of primitive semantic particles are organized in a property tree:

$V_1$

$P_1\ P_2\ \ P_3$
\ | / ..
$P_k$ --- o --- $P_i$
.. / | \ ..
$P_{j+1}\ P_j\ \ P_{j-1}$

$V_2$ `

$P_1$--- o --- $P_2$
/ | \
$P_3\ \ P_4\ \ P_5$_
/ \ | \
$P_6\ \ P_7\ \ \ P_8\ \ P_9$
|
$P_{10}$

We can assign a semantic significance vector $\mathbf{w}_j(V)$ for each property $P_j(V)$ and its parent $par\left(P_j, V\right)$.

$\mathbf{w}_j$

$par\left(P_j\right)$ --------- $P_j$ $V$

Following the semantic tree notation (for details see [Semantic Tree Operations]) for property tree of the particle $V_1$ below

$V_1$

$P_1$
/ \
$P_2$ $P_3$
/ | \
$P_4\ \ P_5\ \ P_6$

$prop\_tree(V_1) = (w_0, P_1) + (w_0 w_1, P_2) + \left(w_0 w_2, \left((1, P_3) + (w_3, P_4) + (w_4, P_5) + (w_5, P_6)\right)\right)$

This is expanded to:

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$prop\_tree(V_1) = (w_0, P_1) + (w_0 w_1, P_2) + (w_0 w_2, P_3) + (w_0 w_2 w_3, P_4) + (w_0 w_2 w_4, P_5) + (w_0 w_2 w_5, P_6)$

From the last relation we can compute the adjusted semantic significance for the particle $V_1$ as

$$w(V_1) = w_0 + w_0 w_1 + w_0 w_2 + w_0 w_2 w_3 + w_0 w_2 w_4 + w_0 w_2 w_5 \qquad (1)$$

Note that all $w$'s in the last equation denote scalar quantities and correspond to one specific dimension in the semantic significance vector space. After applying (1) for each dimension we obtain the semantic significance vector of the particle $V_1$:

$$\mathbf{w}(V_1) \;=\; \sum_j^J \left(w_0^j \;+\; w_0^j w_1^j \;+ w_0^j w_2^j + w_0^j w_2^j w_3^j +\; w_0^j w_2^j w_4^j +\; w_0^j w_2^j w_5^j\right)\mathbf{e}_j \qquad (2)$$

Here $\mathbf{e}_j, j = 1..J$ are the unit vectors for the dimensions of the semantic significance space.

## Semantic significance of composite semantic particle

Let us consider the simplest possible composite semantic particle which is constructed from two primitive particles $V_1$ and $V_2$ connected by the association particle $A$ with semantic significance vector $\mathbf{w}$.

```
           ______    Vc
        __|      |__
     __|     A      |__
    |    V1 --- V2     |
    |__      w       __|
       |__        __|
          |______|
```

Let us denote by $I_1$ and $I_2$ the number of properties in $V_1$and $V_2$ accordingly. Hence $|prop\_set(V_1)| = I_1$ and $|prop\_set(V_2)| = I_2$.
Based on our analysis in the previous section we can rewrite (2) in a more general form:

$$\mathbf{w}(V_2) \;=\; \sum_j^J P_2\left(w_0^j, w_1^j, \dots, w_{I_2}^j\right)\mathbf{e}_j \qquad (3)$$

where $P_2\left(w_0^j, w_1^j, \dots, w_{I_2}^j\right)$ is some polynomial with respect to the scalar semantic significance values corresponding to each property on the property tree of $V_2$. Note that the scalar values $w_1^j, \dots, w_{I_2}^j$ can indeed be matched to specific properties on the property tree of $V_2$ but $w_0^j$ cannot. Indeed $w_0^j$ has free running value for all semantic significance dimensions and if we are calculating the semantic significance of the particle $V_2$ in isolation we simply set $w_0^j = 1 \;\forall\, j = 1..J$. However, if $V_2$ is connected to another particle via the association $A$ with its own semantic significance $\mathbf{w}(A)$ then we can reduce the semantic significance of the structure $A^* = A - V_2$ to a new adjusted vector $\mathbf{w}(A^*) = \mathbf{w}(A - V_2) = \sum_j^J P_2\left(w^j, w_1^j, \dots, w_{I_2}^j\right)\mathbf{e}_j$ where $\mathbf{w}(A) = \sum_{j=1}^J w^j \mathbf{e}_j$. Then

$$\mathbf{w}(V_c) = \mathbf{w}(V_1 - A - V_2) = \sum_{i=1}^J P_1\left(w_0^i, w_1^i, \dots, w_{I_1}^i\right)\mathbf{e}_i - \sum_{j=1}^J w_0^j P_2\left(w^j, w_1^j, \dots, w_{I_2}^j\right)\mathbf{e}_j \qquad (4)$$

The vector $\mathbf{w}(V_c)$ represents the semantic significance vector of the compound particle $V_c$.
Note that each scalar value of $w_j(V_c)$ is polynomial of $I_1 + I_2 + 2$ parameters $w_0^j, w_1^j, \dots, w_{I_1}^j, w^j, w_1^j, \dots, w_{I_2}^j$ one of which , $w_0^j$, is a free parameter and if we calculate the semantic significance of particle $V_c$ in isolation we set $w_0^j = 1 \;\forall\, j = 1..J$.

## Semantic significance of a semantic structure with inbound is-a relations

Let us assume that $R$ represents inbound *is-a* relation for $S_{new}$. That is, $R$ is a *is-a* association between a particle $V_{new}$ in $S_{new}$ and $S$ in $C$. First, let us identify which are the factors which influence the

significance of the inbound *is-a* link. Let by $\mathcal{W}_S$ we denote the set of semantic significance vectors in $S$. Similarly, by $\mathcal{W}_{S_1}, \dots, \mathcal{W}_{S_k}$ we denote the set of the semantic significance vectors in $S_1, \dots, S_k$.
Let us denote by $A^1, A^2, \dots, A^I$ the set of all $A$ particles which belong to structure $S$. Accordingly, by $\mathbf{w}^1, \mathbf{w}^2, \dots, \mathbf{w}^I$ we denote the semantic significance vectors for those $A$ particles in $S$. Let denote the number of scalar components in each $\mathbf{w}^i$ by $J$. Hence $J$ represents the number of semantic significance dimensions in $S$ i.e. $J = \dim \mathbf{w}^i$.
Then one can define the following vector:

$$\mathbf{w}_S^{min} = \left[\min_i w_1^i, \min_i w_2^i, \dots, \min_i w_J^i\right]$$

Thus, for each semantic significance dimension we select the minimal scalar value from the set of semantic significance vectors which pertain to $S$. Let us assume that there are $k$ inbound *is-a* associations to $S$ - $R_1, R_2, \dots, R_k$ linking $V_1, V_2, \dots, V_k$ in $S$ with $S_1, S_2, \dots, S_k$ in $C$. How would we rank them and assign semantic significance vector to each of those *is-a* relations? How would the semantic significance vectors of the relations $R_1, \dots, R_k$ impact the semantic significance vector of $R$? Let us denote with $\mathbf{w}_{R_1}, \dots, \mathbf{w}_{R_k}$ the semantic significance vectors of $R_1, \dots, R_k$. Let us denote with $\mathbf{w}_1, \dots, \mathbf{w}_k$ the semantic significance vectors of the $A$ particles connecting $V_1, \dots, V_k$ with their parents in $S$:

```
                          _________________
                  _______|                 |___________
           ______|               S                     |_____________
 ______|                                                             |______
|                                                                           |_____
|            w_1                   w_2                          w_k               |__
|   P(V_1) ----> V_1      P(V_2) ----> V_2          ...      P(V_k) ----> V_k      _|
|_________________________________________________________________________________|
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