

## Note on binding of an association particle to semantic particles

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### Primitive semantic particles

Let us consider two primitive semantic particles -  $V_i$  and  $V_j$  connected through association particle (link)  $A_{i,j}$ .

$$V_i \text{---} A_{i,j} \text{---} V_j$$

The particles  $V_i$  and  $V_j$  are represented by their semantic signatures  $\mathbf{V}_i$  and  $\mathbf{V}_j$ . The association link  $A_{i,j}$  is represented with its association matrix  $\mathbf{A}_{i,j}$  and semantic significance vector  $\mathbf{W}_{i,j}$ .

The association matrix  $\mathbf{A}_{i,j}$  captures the affinity force  $F(V_i, V_j, t)$  between the particles  $V_i$  and  $V_j$  at the time  $t$  of constructing the compound structure involving those particles. Note that the magnitude of affinity force between the particles may change as their semantic positions and signatures are altered in the future. A change in the affinity force  $F(V_i, V_j, t + \Delta t)$  at a future moment  $t + \Delta t$  may change the matrix  $\mathbf{A}_{i,j}$  of the association link between the altered particles. Altering the semantic position of a particle will require reevaluating the semantic links of this particle with the relevant enclosing contexts.

The association matrix has the following structure:

$\mathbf{A}_{i,j} = [\mathbf{a}_{p_1, q_1} \dots \mathbf{a}_{p_m, q_n}]$  where the pairs  $p, q$  denote all relevant property pairs where the left property belongs to  $V_i$  and the right property belongs to  $V_j$ . Let us denote with  $\mathcal{P}$  the set of property indices which belong to  $V_i$  and with  $\mathcal{Q}$  the set of indices which belong to  $V_j$ . Then  $p \in \mathcal{P}$  and  $q \in \mathcal{Q}$ . Note that the map  $\mathcal{P} \rightarrow \mathcal{Q}$  is many-to-many. That is, the same index  $p$  may appear multiple times with different  $q \in \mathcal{Q}$  and the same index  $q$  may appear multiple times with different  $p \in \mathcal{P}$ . The property association matrices  $\mathbf{a}_{p,q}$  have the following structure:

$$\mathbf{a}_{p,q} = \begin{bmatrix} \mathbf{r}_1^p & \mathbf{r}_1^q \\ \mathbf{0} & \mathbf{0} \\ \mathbf{r}_2^p & \mathbf{r}_2^q \\ \mathbf{0} & \mathbf{0} \\ \vdots & \vdots \\ \mathbf{0} & \mathbf{0} \\ \mathbf{r}_k^p & \mathbf{r}_l^q \end{bmatrix}$$

So  $\mathbf{a}_{p,q}$  is a two-column matrix of size  $N \times 2$  with non-zero regions in each column denoted by the vectors  $\mathbf{r}_i$  where  $\sum_i^k \text{size}(\mathbf{r}_i^p) \leq N$  and  $\sum_j^l \text{size}(\mathbf{r}_j^q) \leq N$ . The non-zero regions  $\mathbf{r}_i^p$  and  $\mathbf{r}_j^q$  are also known as the **active regions** of the association link between the two properties  $P_p \in \text{ptree}(V_i)$  and  $P_q \in \text{ptree}(V_j)$  at time  $t$ . For details refer to [Note On Binding Of An Association Property to Semantic Properties](#).