Appendix

Mathematical Definition of Metagraph

Nodes and Metanodes

A metagraph $G_m = \{V, E\}$ consists of a finite set V of nodes and a finite set E of edges. Nodes in a metagraph can be denoted as $V = \{V_s, V_m\}$ where V_s represents the set of simple nodes as generally defined in simple graph and V_m represents the set of metanodes. The subscript s represents the simple node/edge and the subscription m represents metanode/metaedge. Each metanode $v_m \in V_m$ contains a subgraph consisting of child nodes and connected edges. In addition, we represent a particular agent (e.g. a particular protein) which may have multiple roles, and therefore multiple instances, each having at least one label in common (e.g. the protein ID) We denote the set instance node by $v \in V$ where $v = \{v_i | i > 0\}$, i labeling the different instances. The statement that two metanodes share a node implies that each metanode contains an instance of the same node.

Views and Semantic Zooming

A metanode v_m has two states, *expanded* or *contracted*; the expanded state manifests the internal subgraph (that is, places all children nodes with their connections into the graph) while the contracted state replaces this subgraph with the single node. The combination of different states of the metanodes for a given metagraph results in multiple ***views*** that are abstract representations of the same underling data. The change of the views for a given metagraph is defined as the dynamics of the metagraph, as shown in Fig. 4B.

Metaedges

Edges in a metagraph are denoted as $E = \{E_s, E_m\}$ where E_s represents simple edges that are generally defined in the simple graph and E_m represents metaedges. Each metanode edge $e_m \in E_m = e_{v_m,v}$ is associated with at least one contracted metanode v_m and is transient: it appears when the metanode is contracted and disappears when one or two connected metanode nodes expanded, i.e, the metaedge is derived from the properties of two connected nodes. The most common derivation of the metaedge is the transfer of edges between their children nodes. For example, when metanode representing the complex *Cln1,2* is contracted in Fig 4B2, the connection between *SWI4* and its child node *CLN1* is transferred to *Clin1,2*. However, metaedges can also be derived from other properties of the metanode. The metaedge shown in Fig. 2 is derived if two complexes share the same protein. The derivation of the metaedge can be generalized as $e_{v_m,v} = g(v_m, v)$, where g is the aggregation function and $v \in V$ can either be a metanode node or a simple node.