Trends in Object-Oriented Software Evolution: Investigating Network Properties

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The growth of social networks is phenomenal.
... but networks (and software) are not static

- Research has focused into the evolution of networks in order to derive models that govern their growth
- Software systems can be naturally represented as graphs
- *Trends in software evolution can be studied using SNA*
- Macroscopic phenomena at the network level might reveal:
  - the presence of design problems
  - the application of maintenance activities
  - the need to formulate “evolution-oriented” design rules
Community Guided Attachment

- Social setting: individuals tend to be similar to their friends (homophily)
  - we select friends that have similar characteristics (selection)
  - we modify our behavior (social influence)
Obviously software modules do not select their collaborators and do not modify their behavior for social reasons.

But, designers of classes make them interact with other classes that are conceptually similar.

Usually modules are organized in distinct communities (e.g. packages, namespaces).
Intuitive Assumption: Cross-package links should be harder to form than intra-package links.
CGA = large percentage of links among classes in the same package

1st version: 40% of the links connect classes residing in the same package

last version: only 30% of the links connect classes residing in the same package
• One of the most extensively studied issues in Network Analysis is whether networks are **scale-free**

• According to many researchers, in a scale-free network the degree distribution follows a **power law** * 

* however power laws in the degree distribution are not sufficient to prove the existence of scale-freeness "Mathematics and the Internet: A Source of Great Potential", Willinger, Alderson, Doyle, Notices of the AMS, 56, 2009
• What leads to scale-free networks and power law phenomena?

• **PA model**: when a network evolves, the number of new links attracted by each node is proportional to its degree.

• “*Rich-gets-richer*”: For an OO system implies that *God* classes act as attractors for new classes that join the network.
Is PA present in software?

- First version: around 50% of new associations attached to nodes having in-degree 50 or higher.
- Last version: 50% of new associations attached to nodes having in-degree 100+.
- Last version: 20% of new associations attached to nodes having in-degree 250+.
Small World Phenomena

- A network is said to exhibit the *small-world phenomenon* if any two nodes have a high probability of being associated through a short path

- Popularly known as *six degrees of separation*
• According to Watts and Strogatz this property stems from homophily and the presence of weak ties (edges that connect distant nodes)

• Both properties are present in OO systems:
  • Classes tend to link to classes in the same neighborhood
  • Links are also formed between classes of different packages
Small World Phenomena - 3

Small world phenomenon becomes less intense

first version: 100% of class pairs are at most 3 hops apart

last version: 100% of class pairs are at most 4 hops apart
Small World Phenomena - 4

• Small-world phenomena are expected when the underlying model of growth follows a “forest-fire” model
Small World Phenomena - 5

• This is not how OO software evolves

[Diagram of class relationships]
Conclusions

- The analysis of evolving software to reveal the underlying trends can be a challenging task.
- Network Analysis can provide valuable insight into evolution phenomena – possibly related to qualitative properties.
- No model sufficient to explain how software evolves.
- Major difference between software and social networks: In software we can intentionally modify structure.
  - Investigate the impact of design improving activities.
Thank you for your attention