Trends in Object-Oriented Software Evolution: Investigating Network Properties

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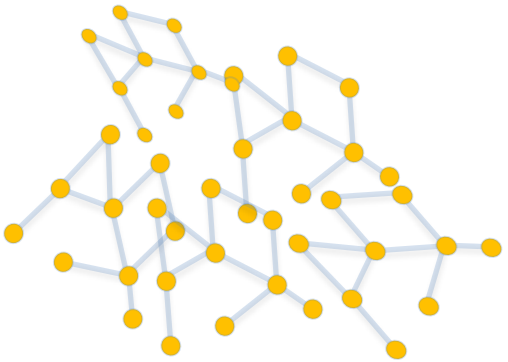

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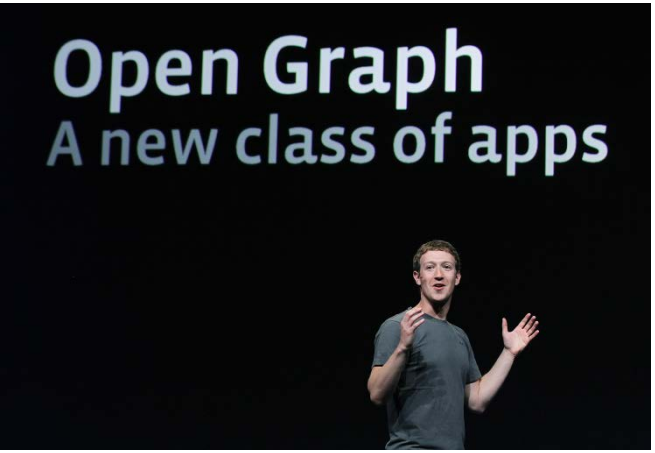
Facts

The growth of social networks is phenomenal



social networks are Graphs

Research on Graph Properties

Social
Network
Analysis

Microsoft Research

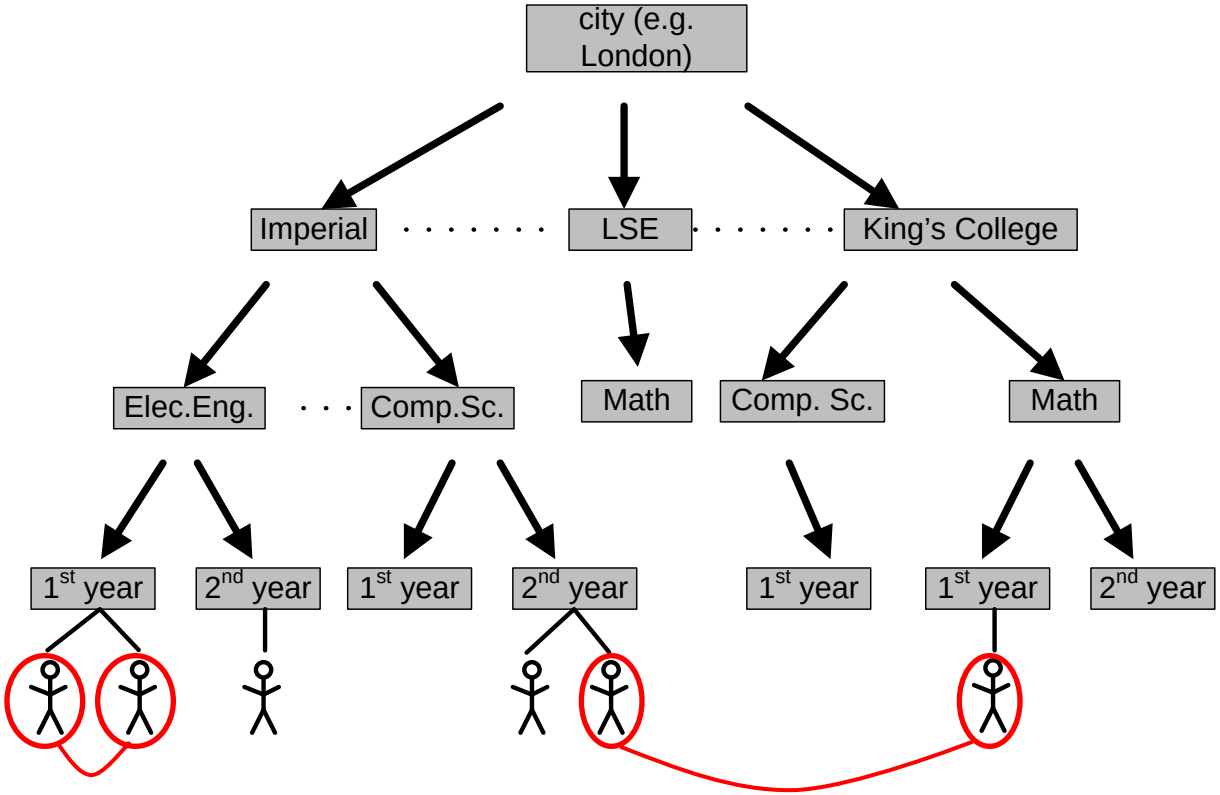
Google Research

… 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)*



Community Guided Attachment - 2

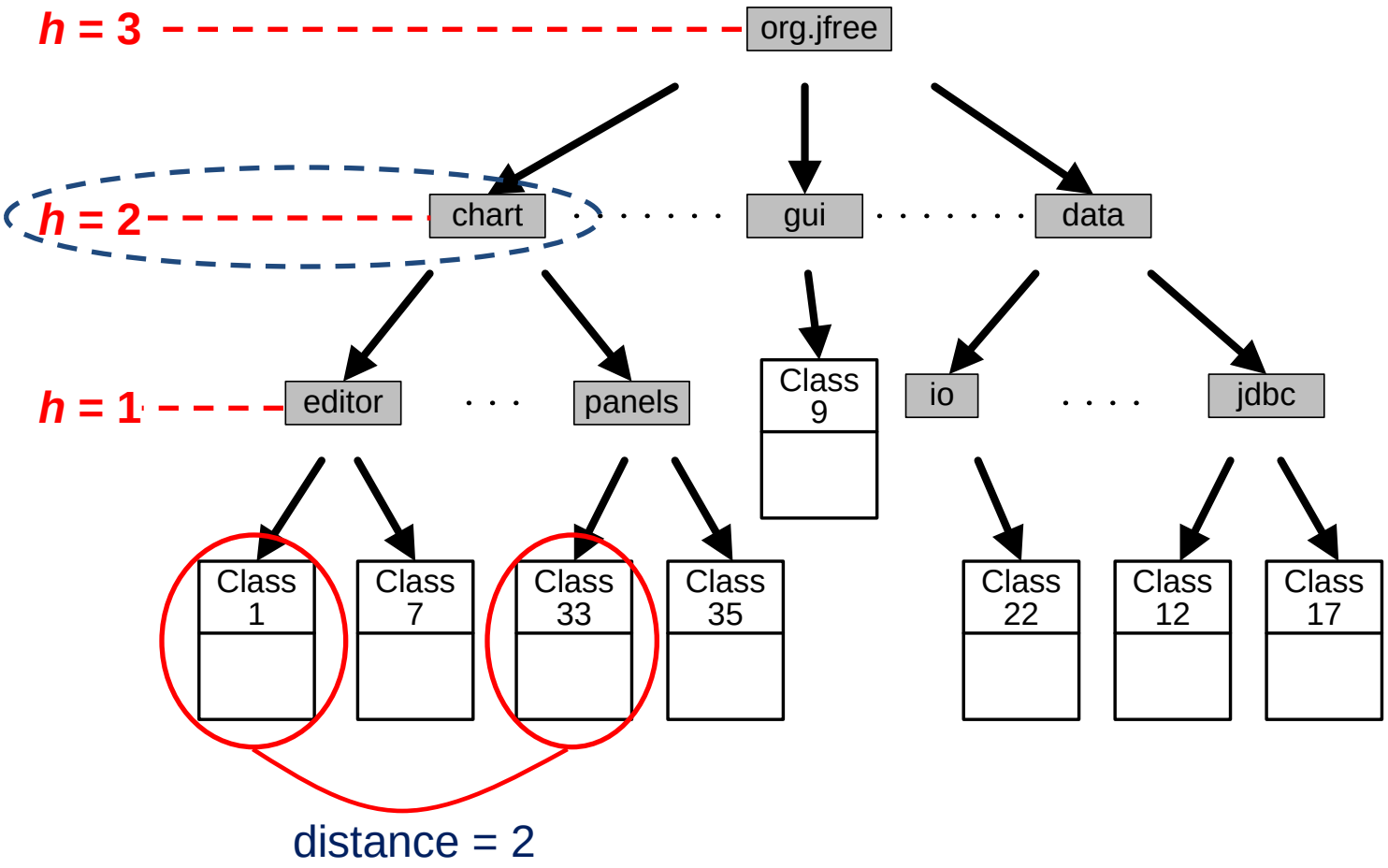
•Obviously software modules do not select their collaborators and do not modify their behavior for social reasons

• 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)

Community Guided Attachment - 3

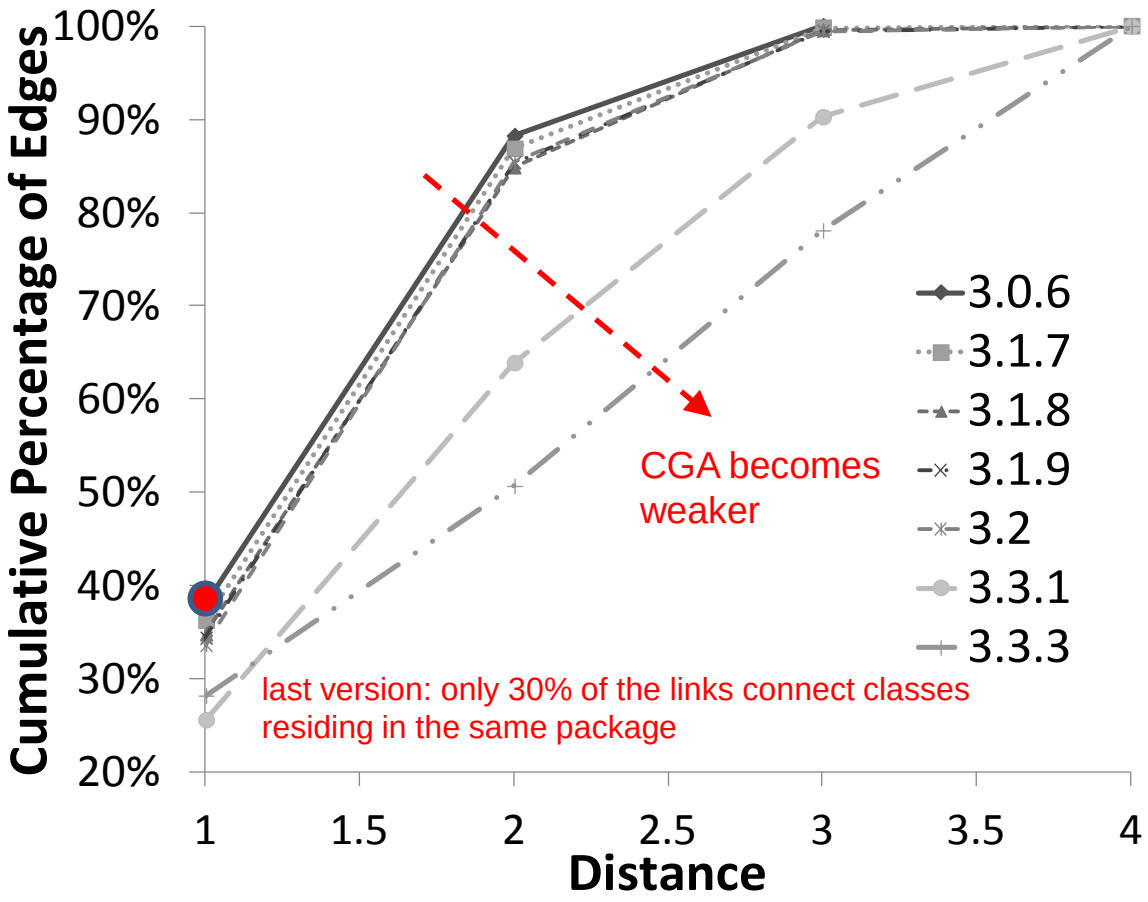
Intuitive Assumption: Cross-package links
should be harder to form than intra-package links



Community Guided Attachment - 4

CGA = large percentage of links among classes in the same package

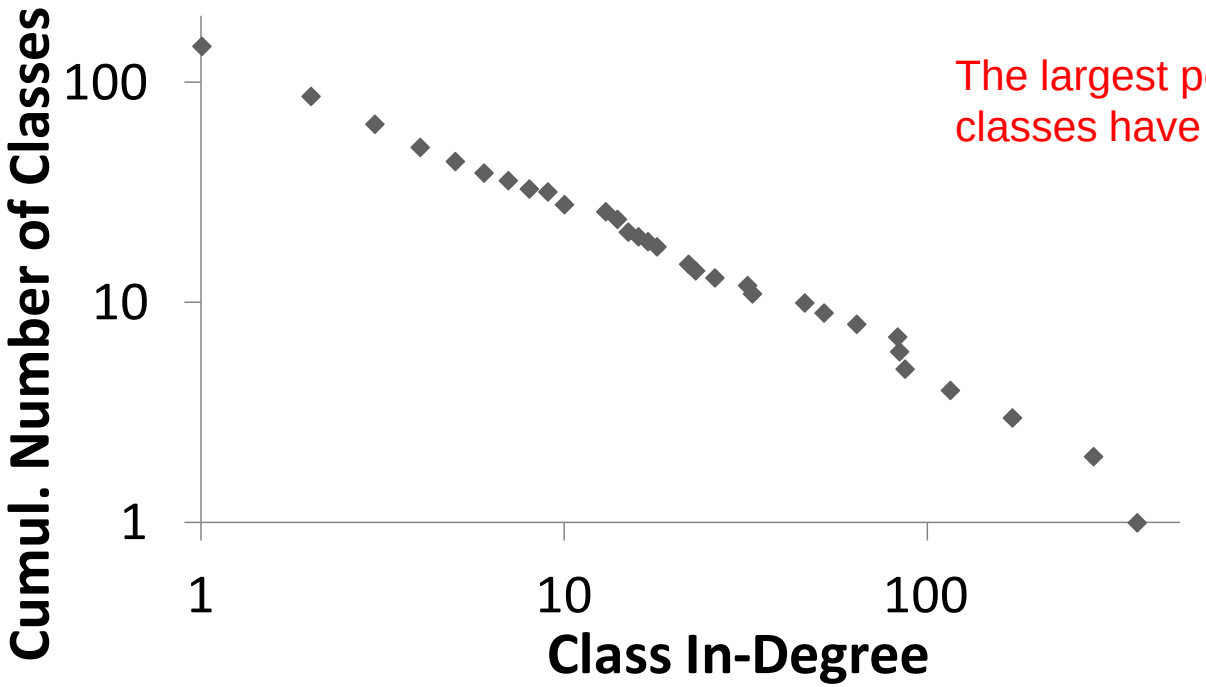
1st version: 40% of the links connect classes residing in the same package



Preferential Attachment

• 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 *



The largest percentage of classes have low in-degree

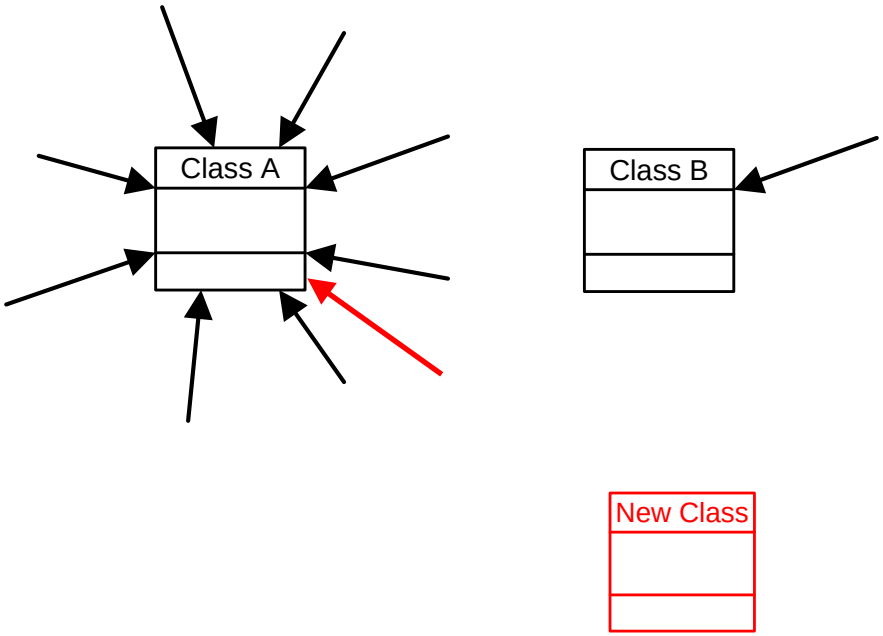
* however power laws in the degree distribution are not sufficient to prove the existence of scale-freeness "Mathematics and the Internet: A Source of Great Potential", *Willinger, Alderson, Doyle,* Notices of the AMS, 56, 2009

Preferential Attachment - 2

• What leads to scale-free networks and power law phenomena ?

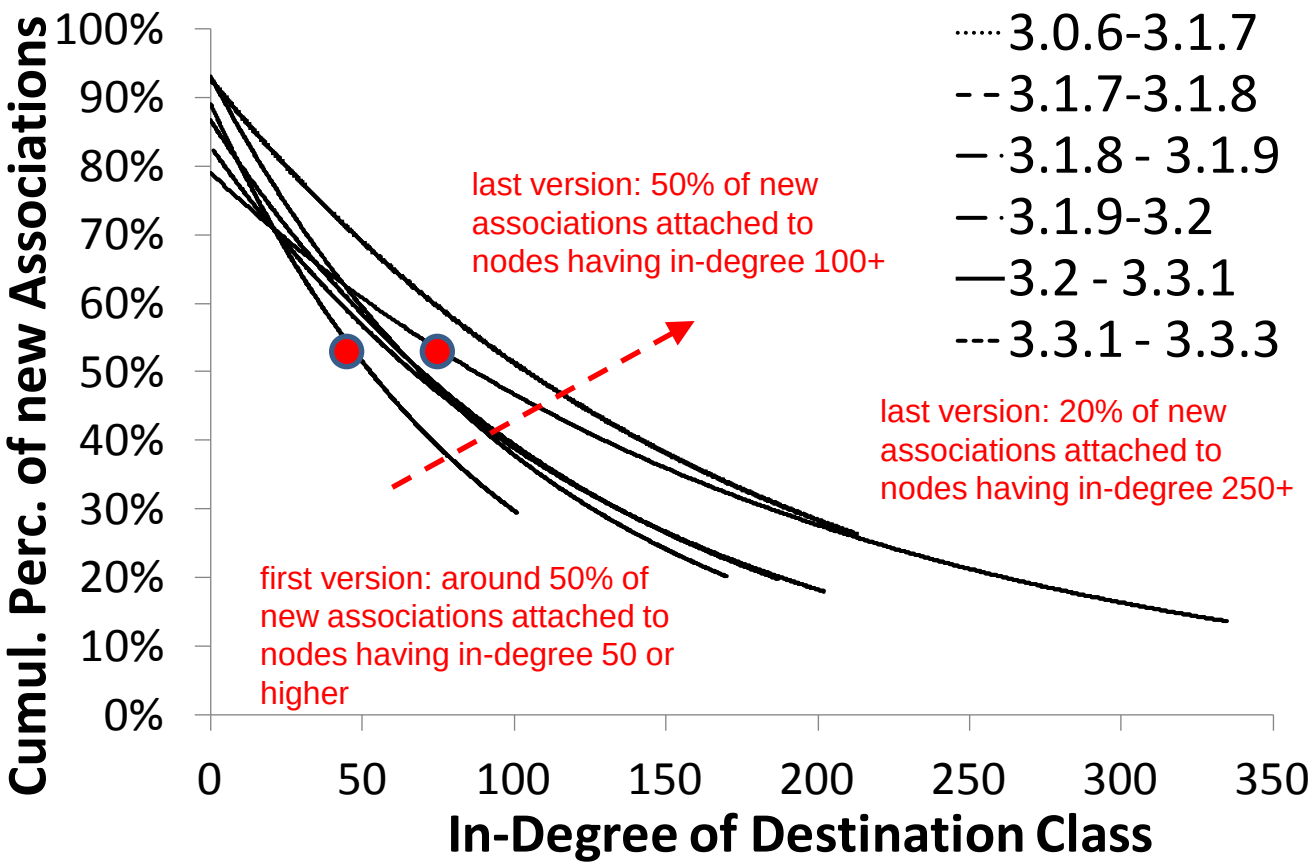
•PA model: when a network evolves, the number of new links attracted by each node is proportional to its degree

• "*Rich-gets-richer*": For an OO system implies that *God* classes act as attractors for new classes that join the network



Preferential Attachment - 3

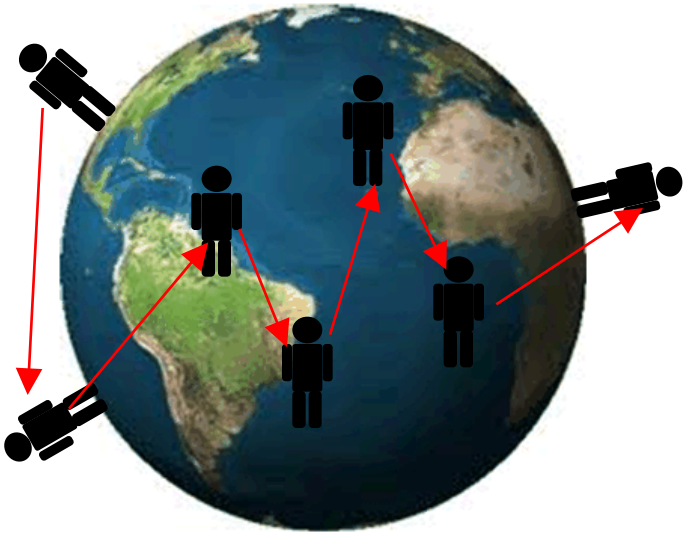
- Is PA present in software ?



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

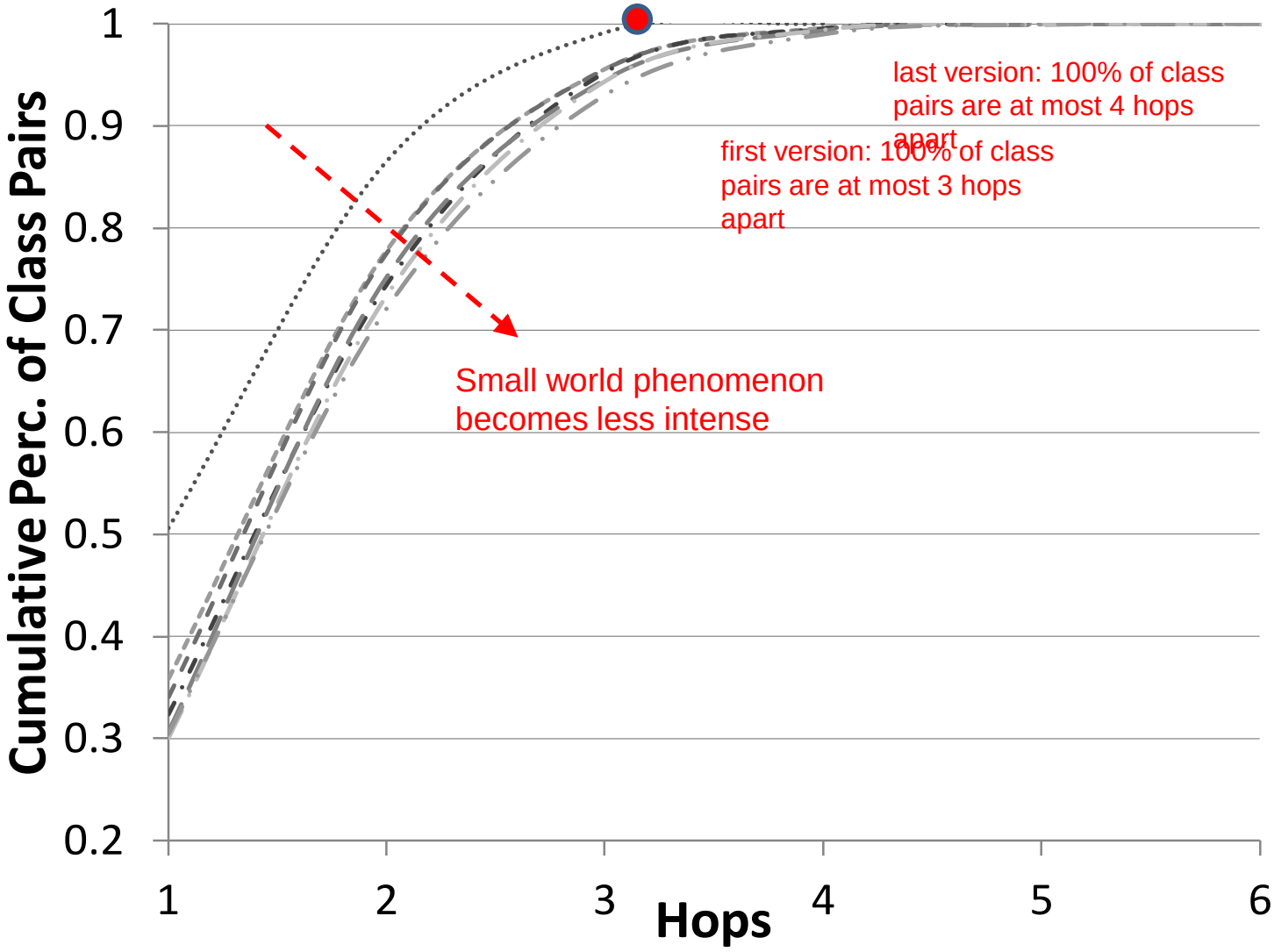
- Popularly known as *six degrees of separation*



Small World Phenomena - 2

- 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

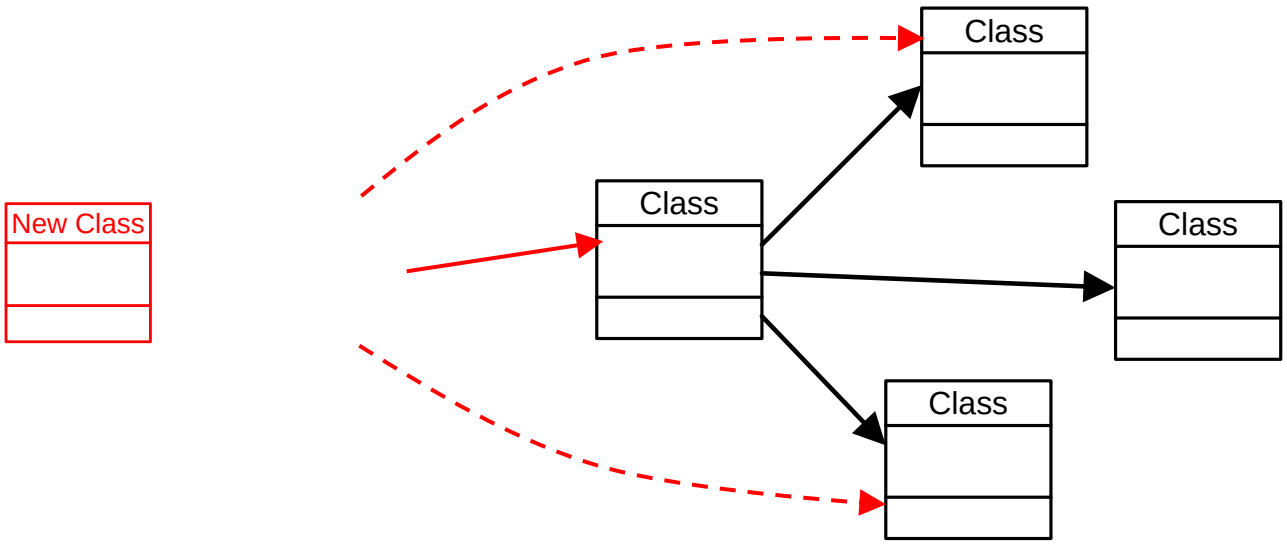


Small World Phenomena - 4

• 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



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