It Takes a Village to Build a Robot:

Understanding the ROS Ecosystem

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Sophia Kolak, Chris Timperley, Afsoon Afzal, Michael Hilton, Claire Le Goues

The ROS vision: Better Together!

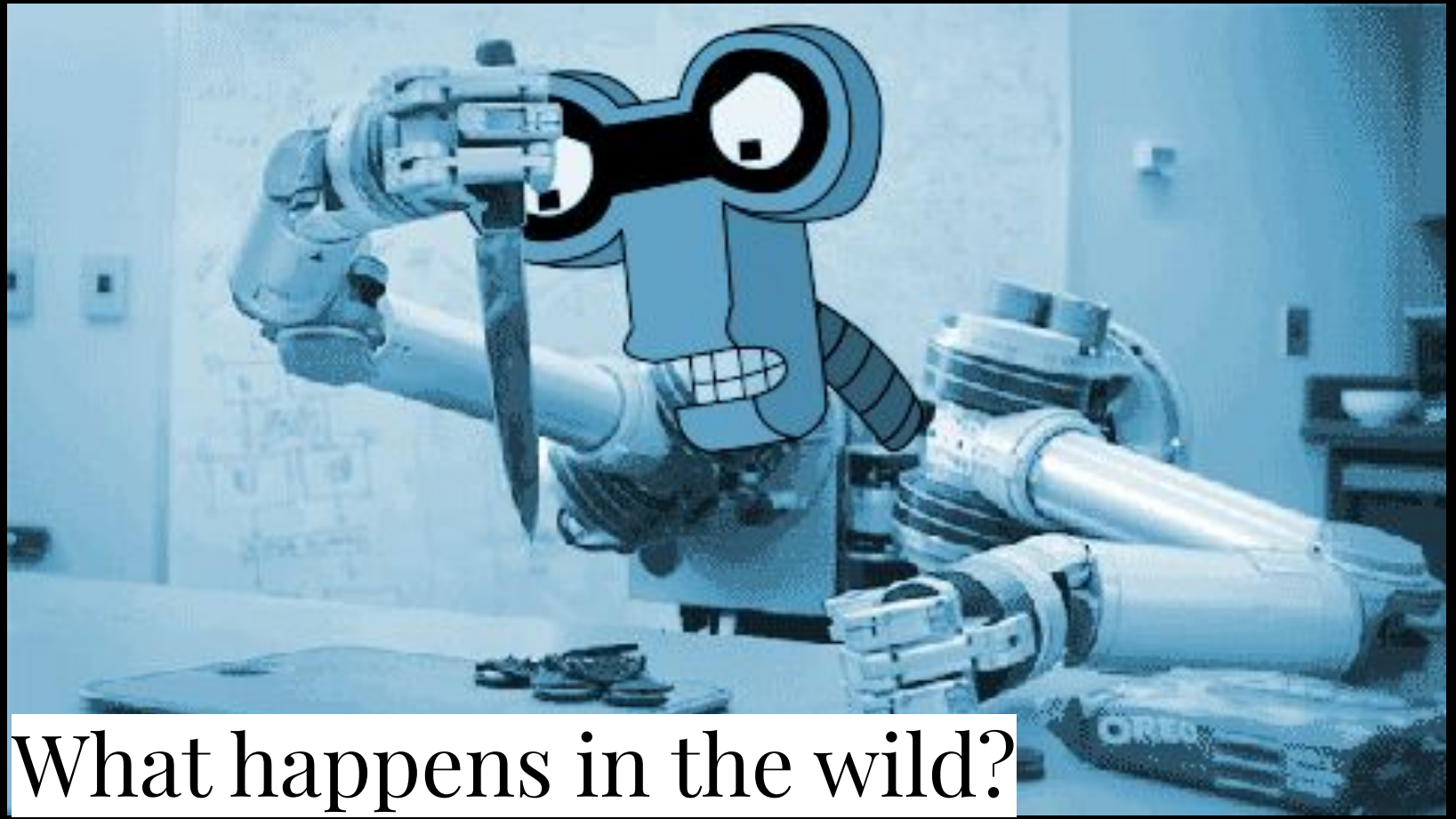
✔ Code reuse

✔ Faster Development

✔ Modularity

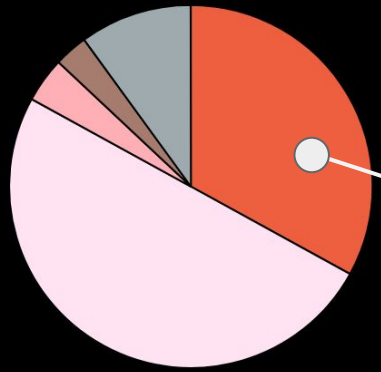
✔ Easier Maintenance

Are we Living up to the Vision?

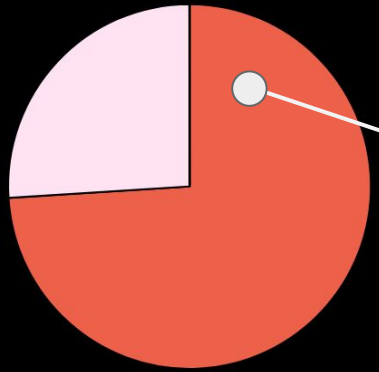


What happens in the wild?

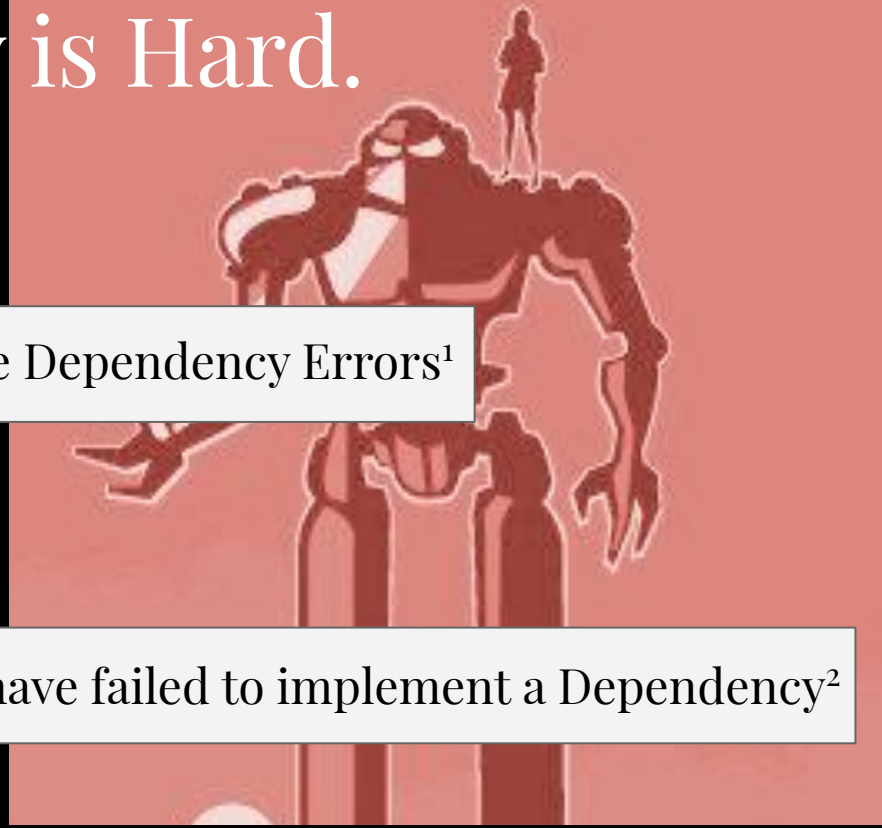
In practice, Modularity is Hard.



33% of ROS bugs are Dependency Errors[1]



74% of ROS users have failed to implement a Dependency[2]



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1, *How ROS cares for Quality, ROSin, ROScon 2017*

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2. Estefo et al., *The Robot Operating System: Package reuse and community dynamics*

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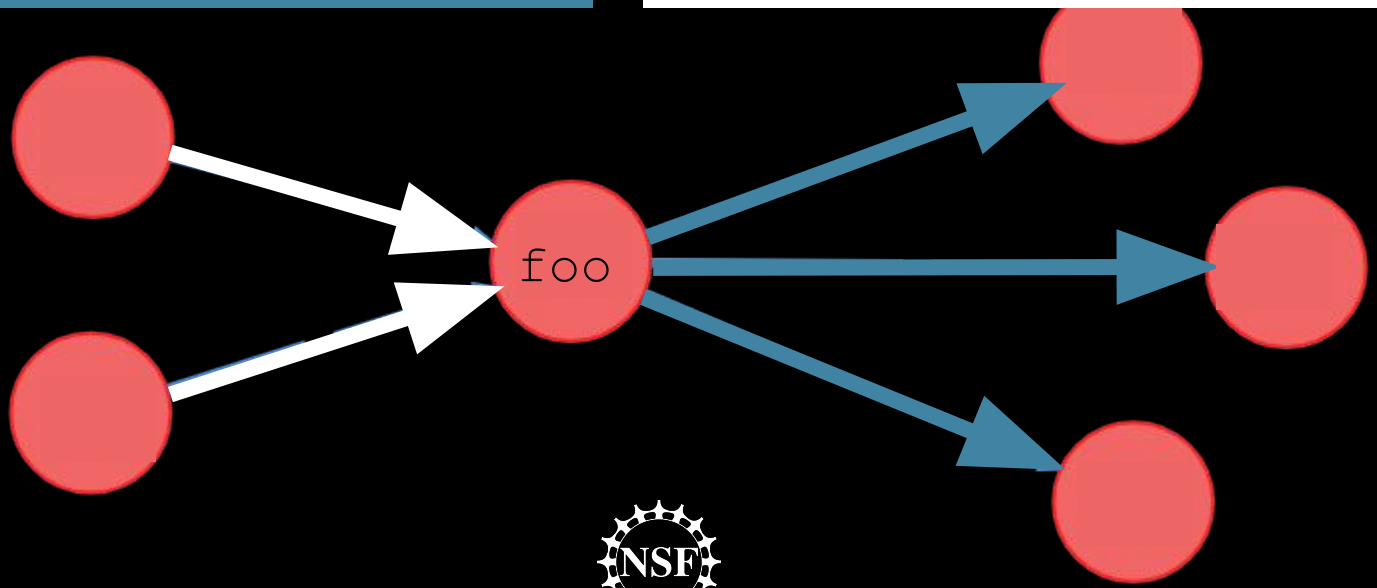
A Deeper Look at **Dependence**:

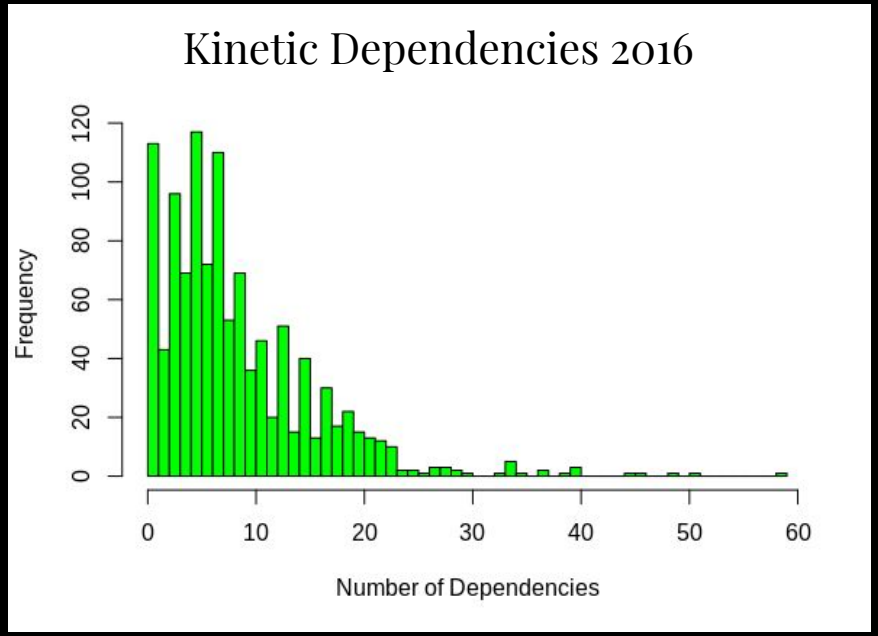
Modeling the ROS Software Ecosystem.

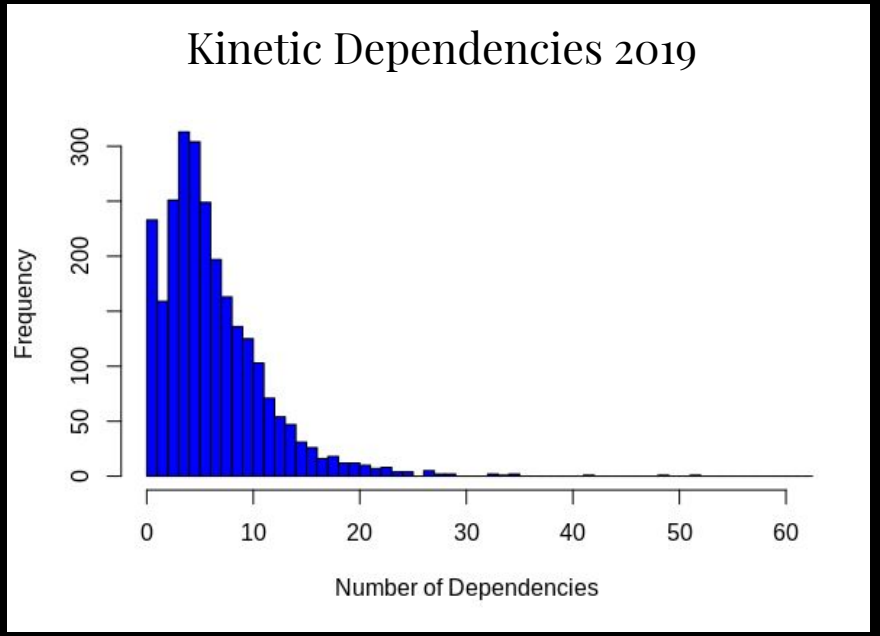
`foo` *is depended on* twice

`foo` *has three dependencies*

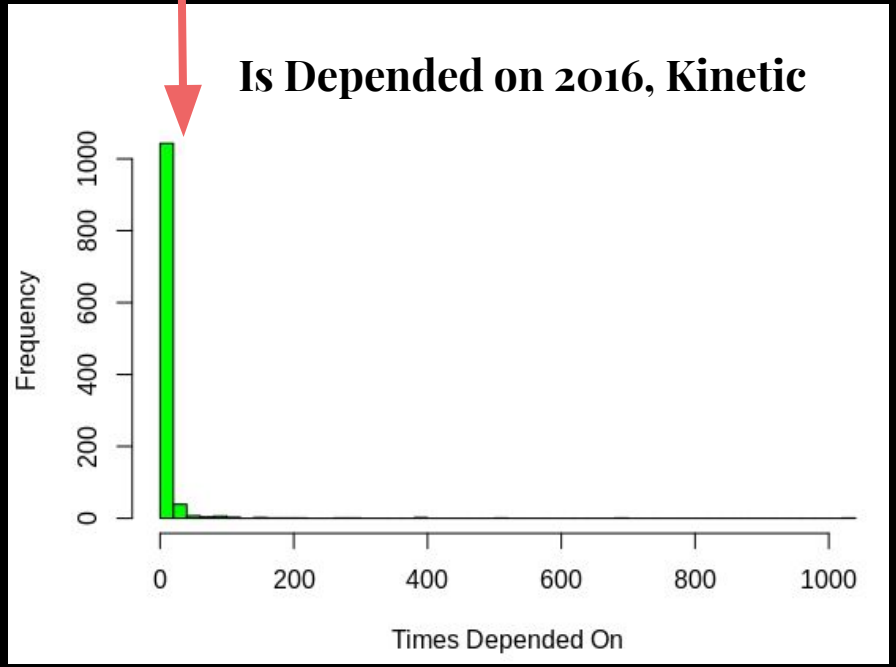


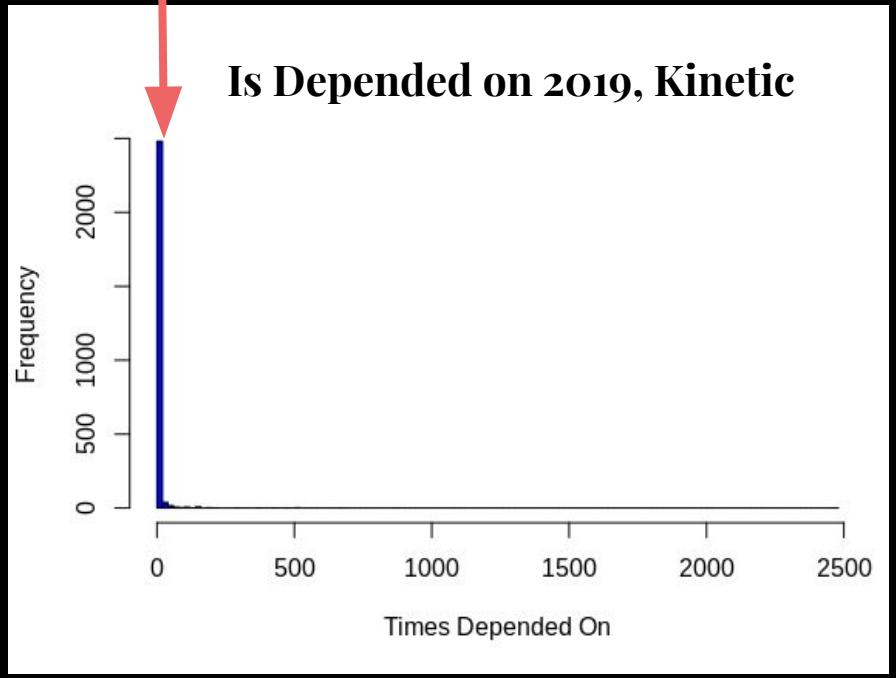
Packages Usually Depend on ~9 Others.



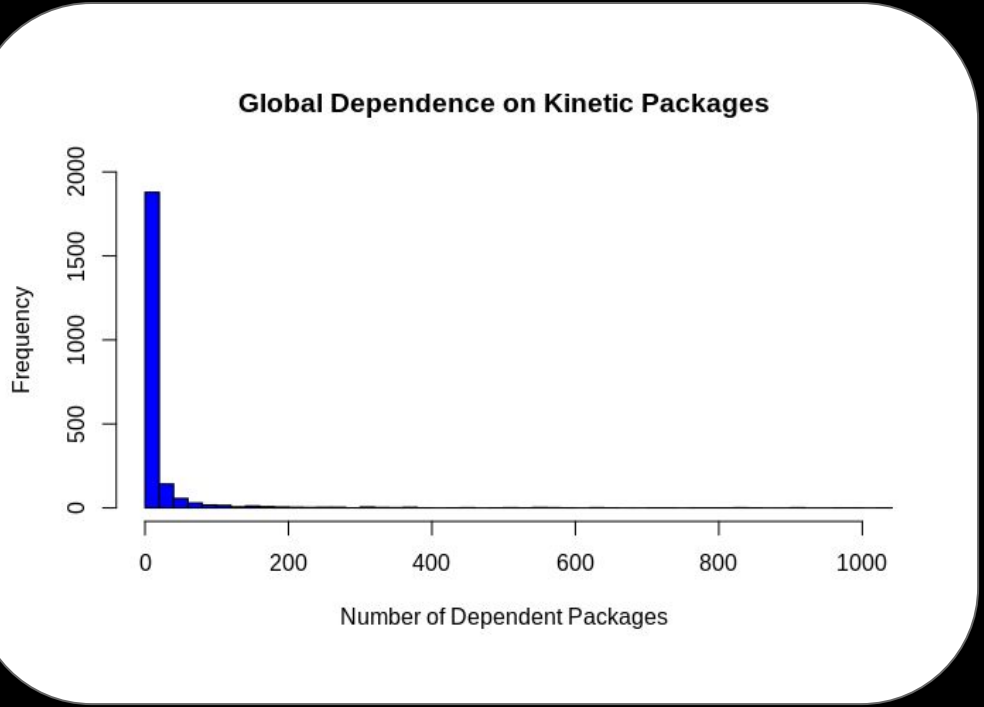


But most packages are never depended on...





A Few Packages Do Most of the Work



~19% have one dependent package

~12% have two dependent packages

~61% of all kinetic packages are depended on globally less than 5 times

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Dependence Inequality?

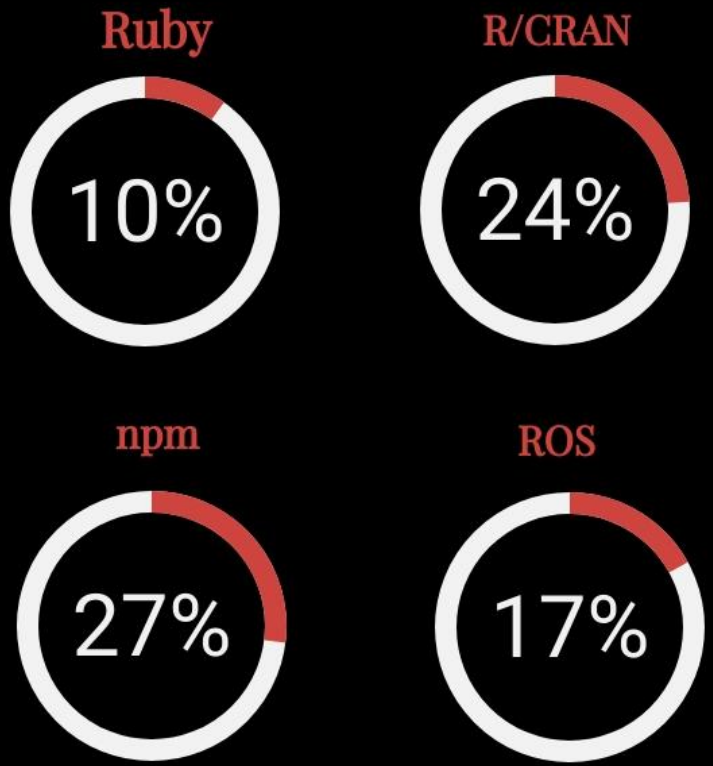
The top 1% of Packages are Depended on More than the bottom 99%.

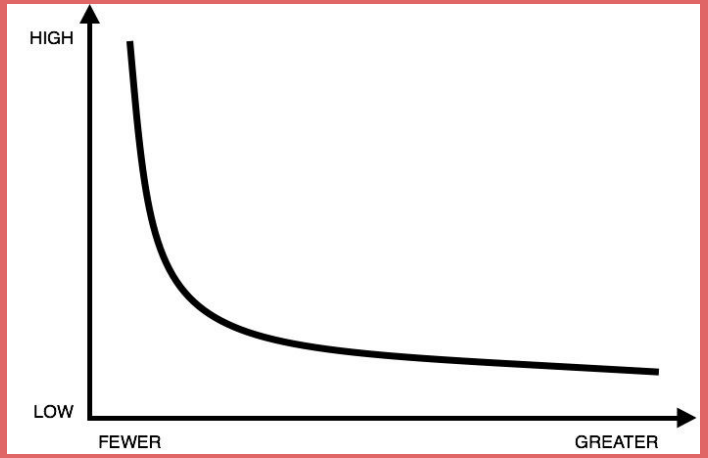
Dependence Inequality?

The top 1% of Packages are Depended on More than the bottom 99%.

So What?

Power laws are common in OSS





"20% of nodes responsible for 80% of result"

In FOSS Ecosystems, Github metrics are often correlated with popularity.

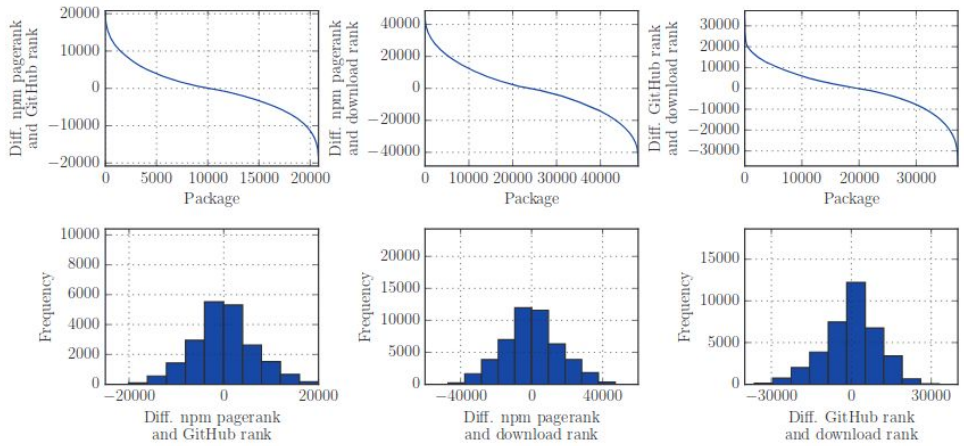
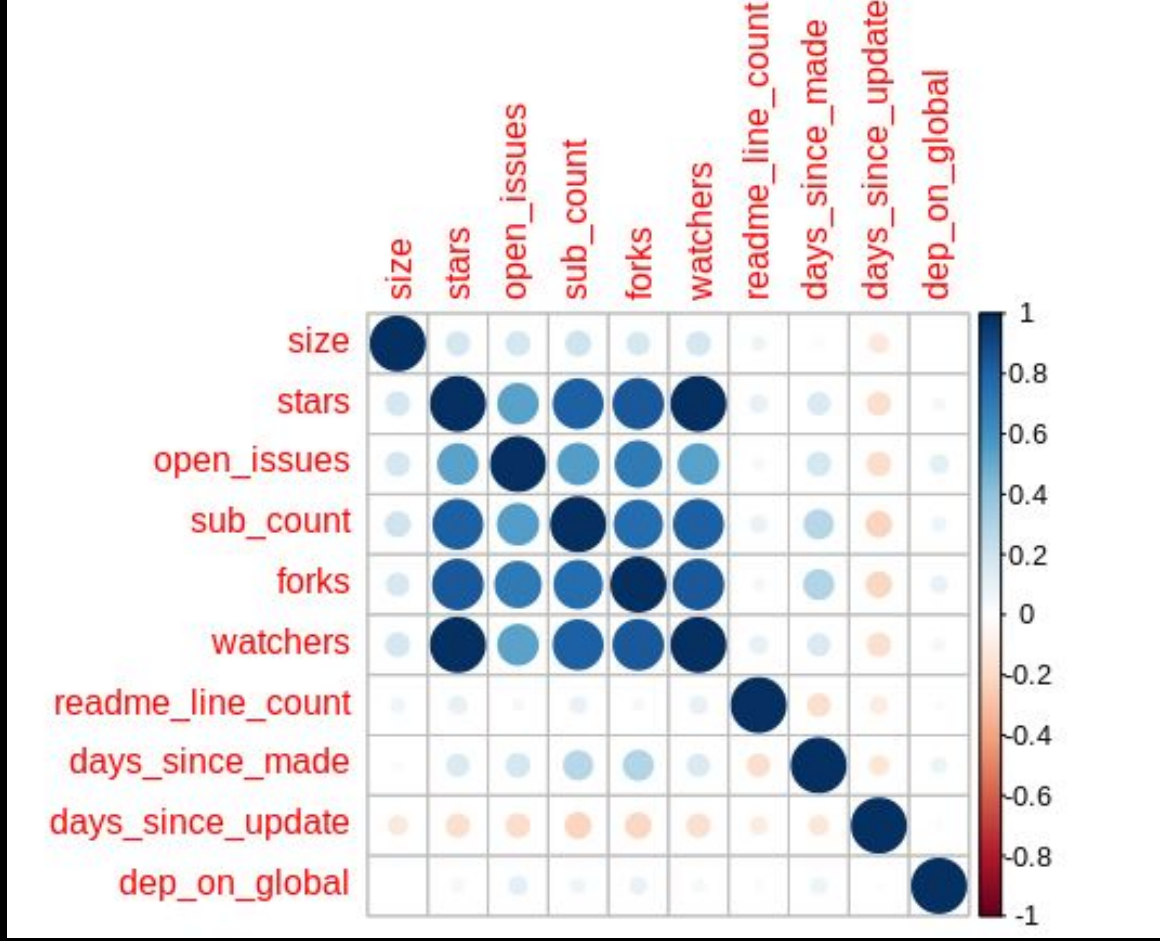


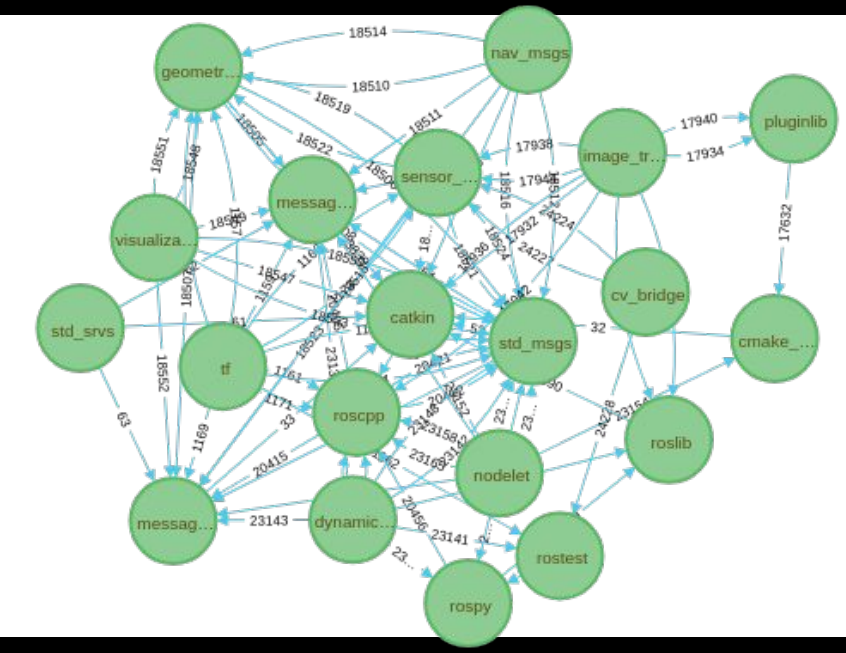
Figure 5: Differences in ranks between popularity measures.

Stars
Forks
Open Issues
Watchers
Size

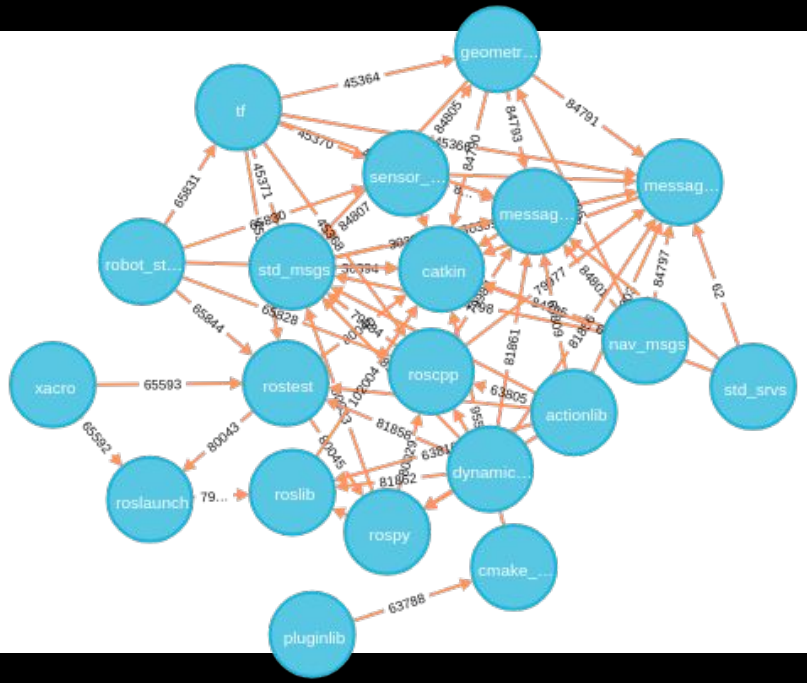
In ROS, Github Metrics Don't Explain Popularity.



Being Maintained by OSRF Matters More.



Top 20, 2016

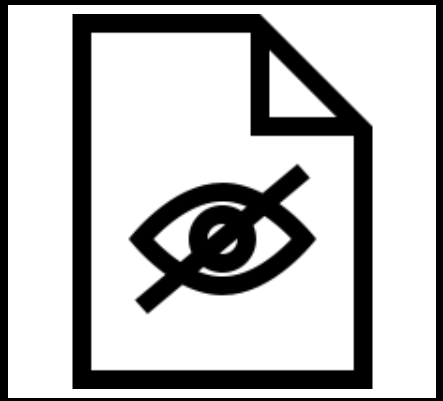


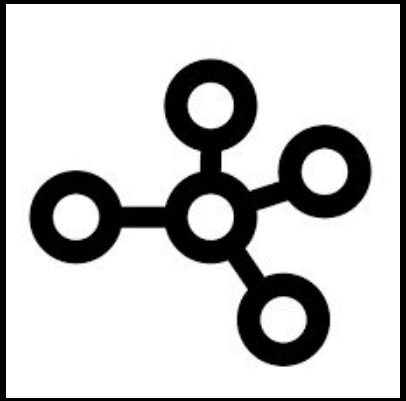
Top 20, 2019

Possible Explanations

- Of 230,000 ROS packages on Github, only 45,000 were uniquely named.
- 8 of the 20 most copied packages are never specified as an explicit dependency.

Not Explicitly Stating Dependencies

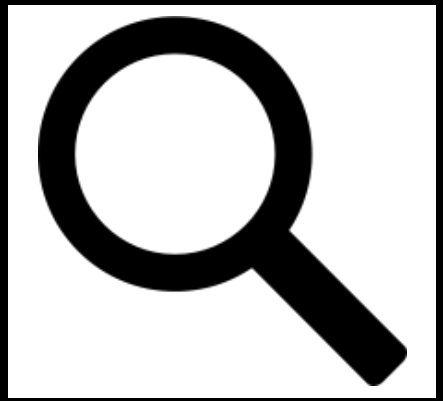


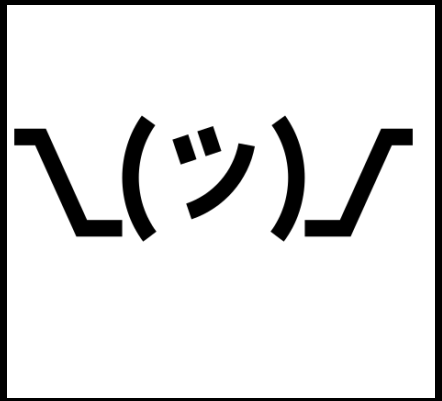


Possible Explanations

- No sophisticated search mechanism
- Many packages are not on ROS index or wiki

Users can't find new packages

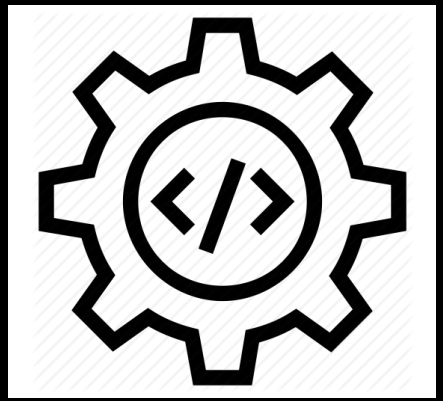


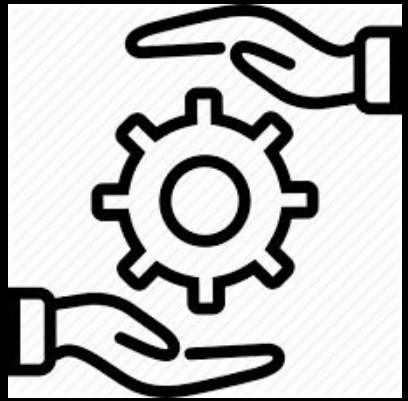


Possible Explanations

- Documentation is often minimal (average readme length is 19 lines)
- Packages rarely state the version they depend on (~1% of the time)
- Not maintained, some packages in ROSdistro were abandoned

Users can't implement new packages





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Suggestions:

- Teach others, document better
- Semantic Search Mechanism
- Explicitly State Dependencies
- Make versioning clear
- Lightweight Vetting process?

Thank You!

- Should we check quality of code in the ROS distro?
- How should the ecosystem evolve for ROS2?
- How did we gather our data?

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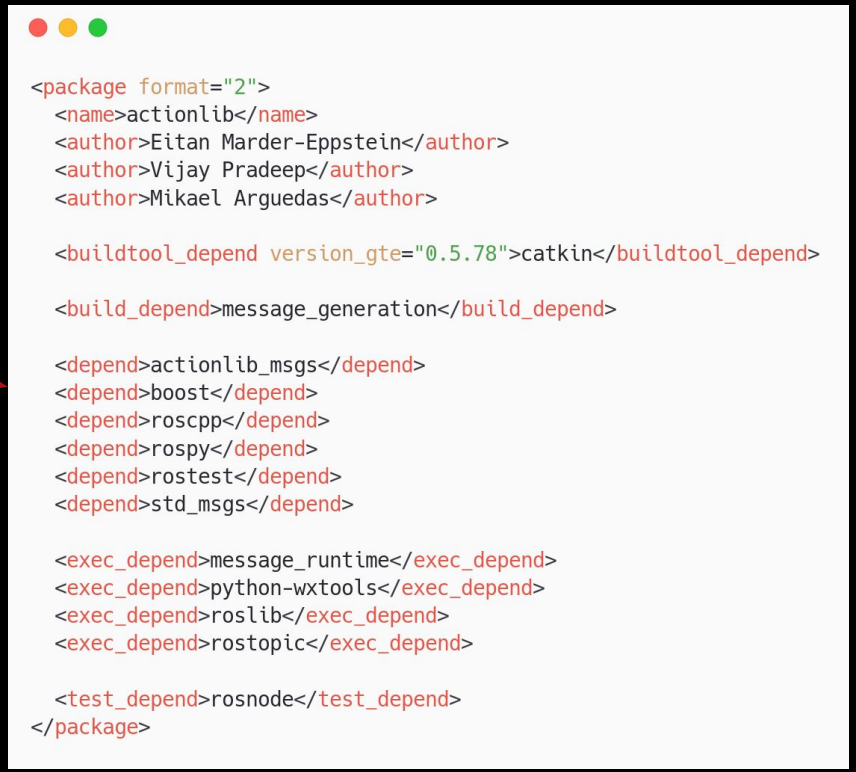
How we structured our data

actionlib
package.xml



```
<package format="2">
  <name>actionlib</name>
  <author>Eitan Marder-Eppstein</author>
  <author>Vijay Pradeep</author>
  <author>Mikael Arguedas</author>

  <buildtool_depend version_gte="0.5.78">catkin</buildtool_depend>

  <build_depend>message_generation</build_depend>

  <depend>actionlib_msgs</depend>
  <depend>boost</depend>
  <depend>roscpp</depend>
  <depend>rospy</depend>
  <depend>rostest</depend>
  <depend>std_msgs</depend>

  <exec_depend>message_runtime</exec_depend>
  <exec_depend>python-wxtools</exec_depend>
  <exec_depend>roslib</exec_depend>
  <exec_depend>rostopic</exec_depend>

  <test_depend>rosnode</test_depend>
</package>
```

actionlib

```
<depend>actionlib_msgs</depend>
<depend>boost</depend>
<depend>roscpp</depend>
```

actionlib

```
<depend>actionlib_msgs</depend>
<depend>boost</depend>
<depend>roscpp</depend>
```

In mySQL...

id	parent_id	child	dep_type
81059	21265	actionlib_msgs	depend
81060	21265	boost	depend
81061	21265	roscpp	depend

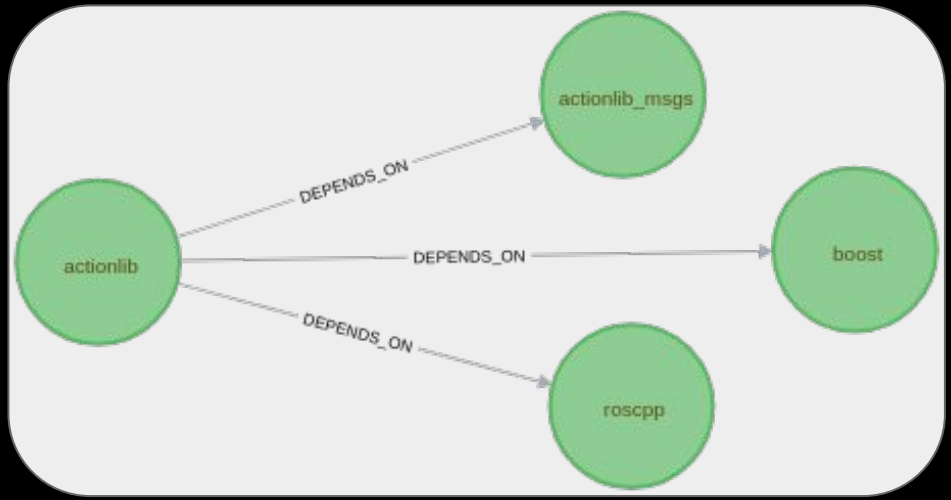
actionlib

```
<depend>actionlib_msgs</depend>
<depend>boost</depend>
<depend>roscpp</depend>
```

In mySQL...

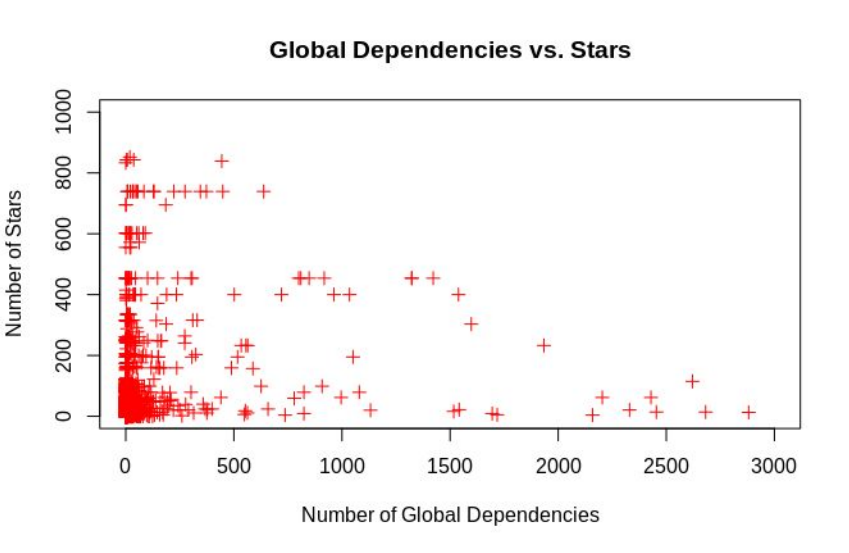
id	parent_id	child	dep_type
81059	21265	actionlib_msgs	depend
81060	21265	boost	depend
81061	21265	roscpp	depend

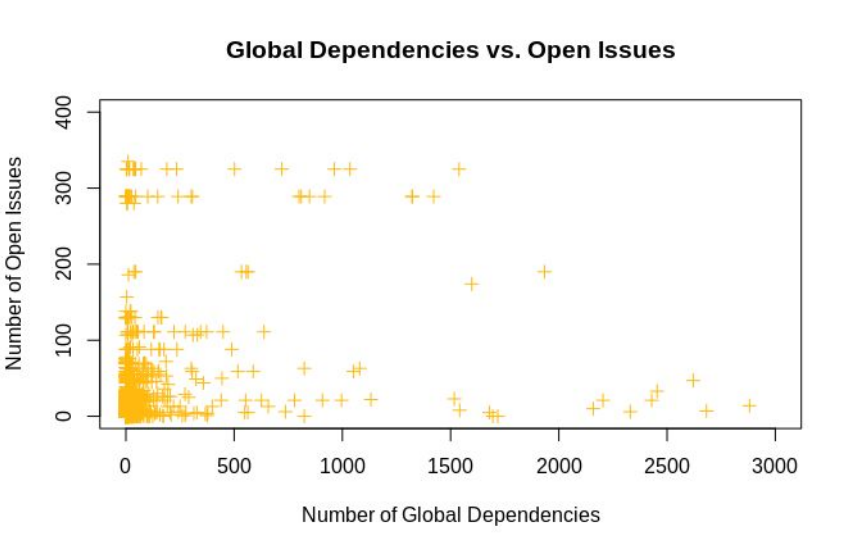
In Neo4j...

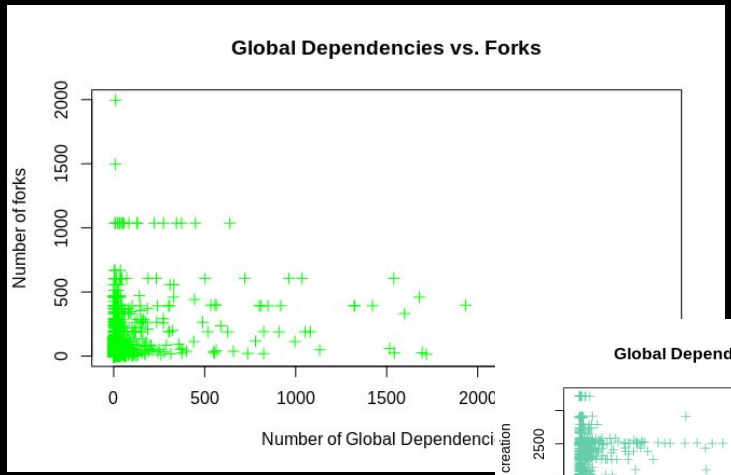


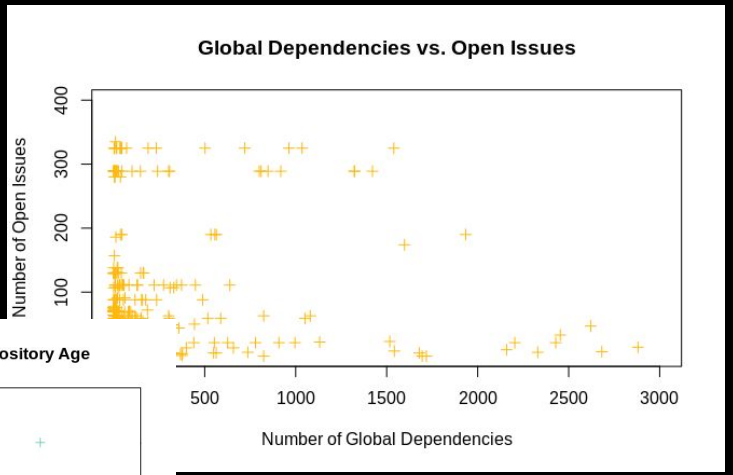
Are Top Packages Just Better?

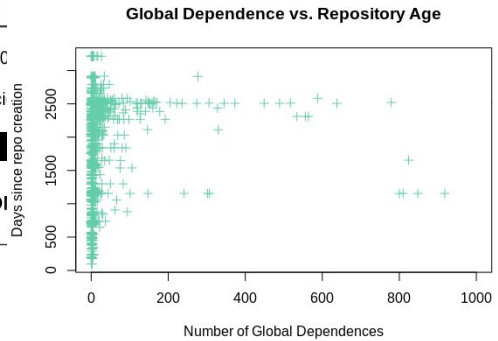
Used Github data as a proxy for quality

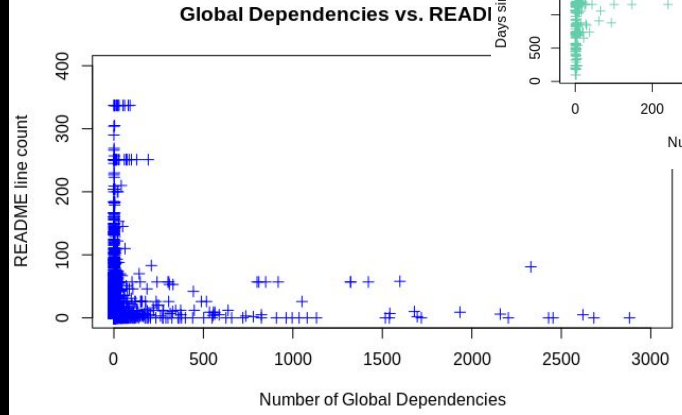


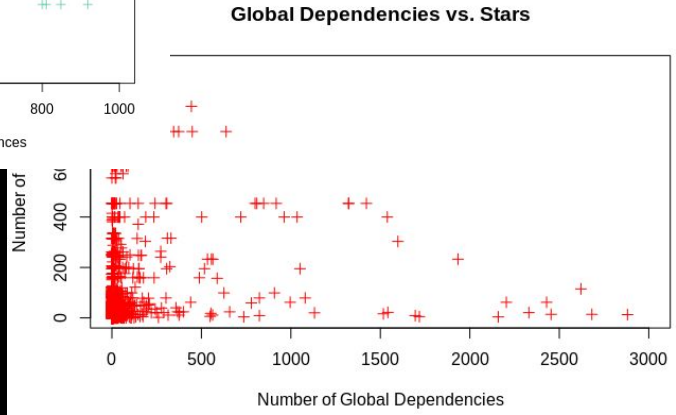












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