

Recommending Source Code for Rapid Software Prototypes

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¹College of William & Mary

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You own a Start-Up

In **two weeks**, you are meeting
with this venture capitalist.

He might invest **>\$1 million** in you.

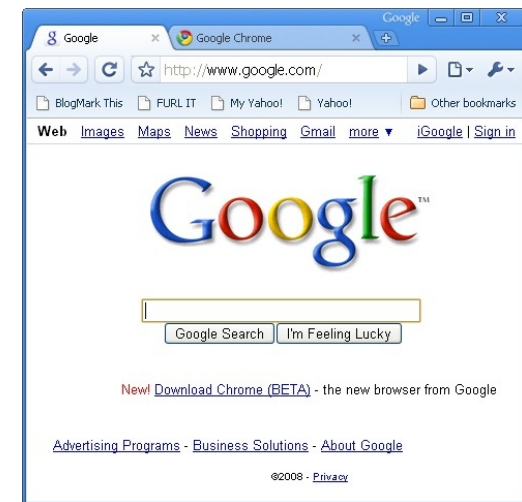
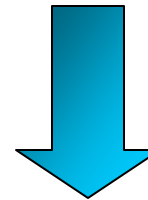


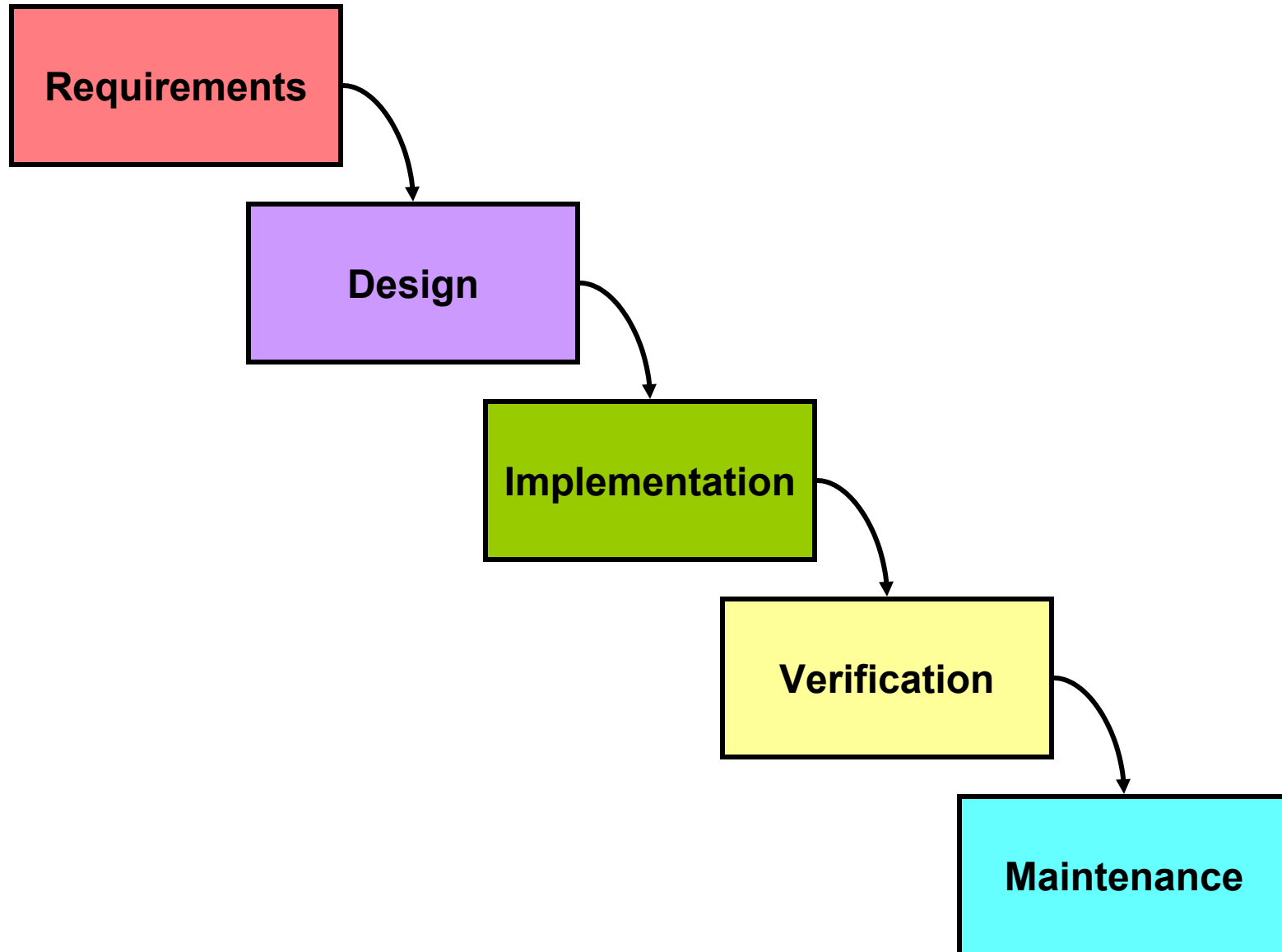
Your Product

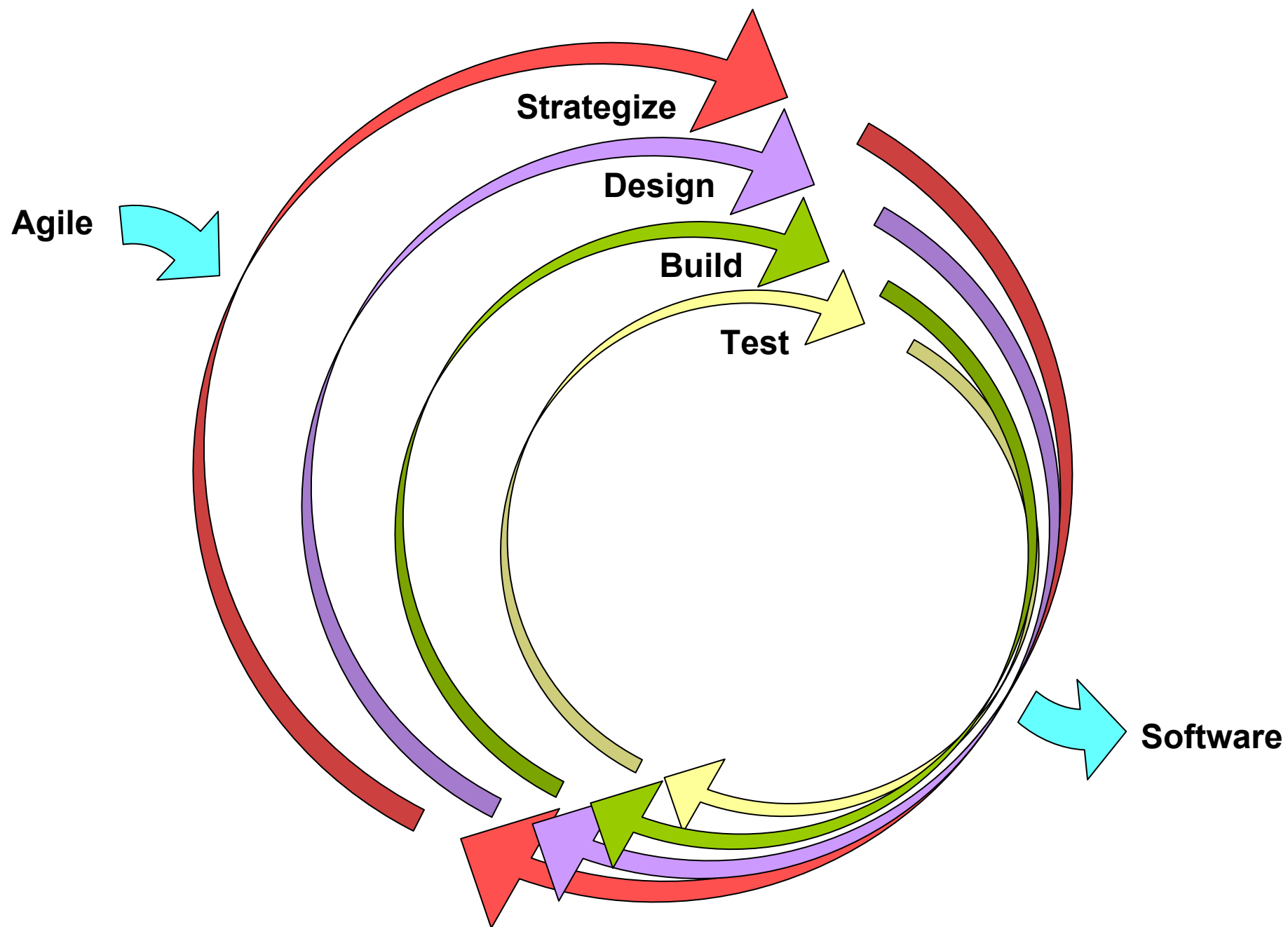
A new web-enabled device is on the market.

You can build the first and only **web browser** for it.

What do we do?







Study Existing Solutions

Feature 1
“browser tabs”



Feature 2
“search bar”

Feature 3
“image downloading”

How can we do that, too?

Feature 1 “browser tabs”



- APIs?
- Existing classes?
- Suitable algorithms?

Step One: Build a Prototype

- Initial version may be buggy, slow, etc.
- Prototypes often **thrown away**
- Known as *opportunistic programming*

* J. Brandt, P. Guo, J. Lewenstein, M. Dontcheva, S. Klemmer.
Opportunistic Programming: Writing Code to Prototype, Ideate, and Discover. IEEE Software, Volume 26, Issue 5 (Sept/Oct 2009).

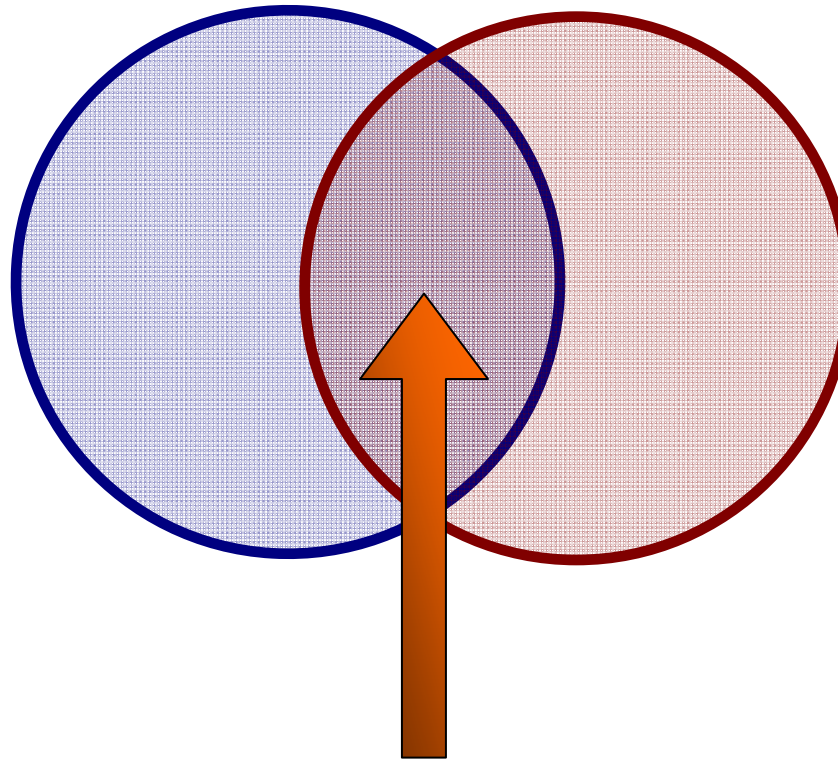
Types of Prototypes

Horizontal: Locate all *features* to implement.



Vertical: *Implement* and
demonstrate select features.

Which Features to Implement?



Recommend the Common Features

Extracting Features from a Software Repository



- Tabbed Browsing
- Print to PDF
- Search Bar
- Mip Map Dithering

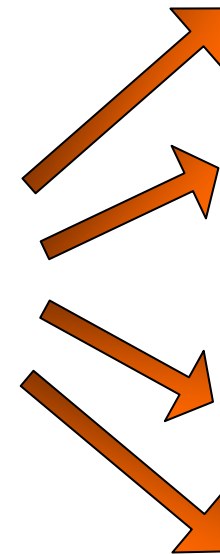
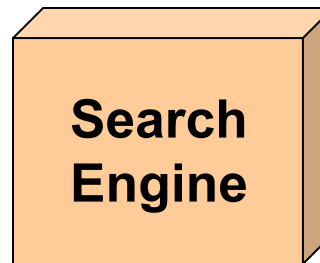
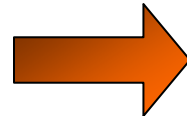
- Email using Outlook
- Browse using Tabs
- Windows Integration
- Pop-up Blocker

* H. Dumitru, M. Gibiec, N. Hariri, J. Cleland-Huang, B. Mobasher, C. Castro-Herrera, M. Mirakhorli, "On-demand Feature Recommendations derived from Mining Public Product Descriptions", ICSE'11.

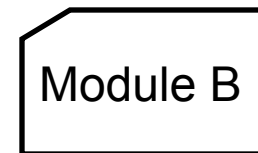
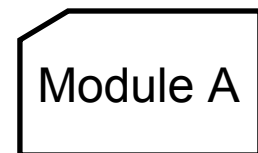
Next: Finding Reusable Source Code

Features

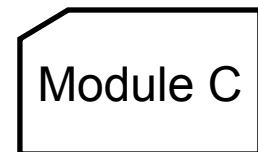
- Tabbed Browsing
- Print to PDF
- Search Bar
- Mip Map Dithering
- Email using Outlook
- Windows Integration
- Pop-up Blocker



Source Code



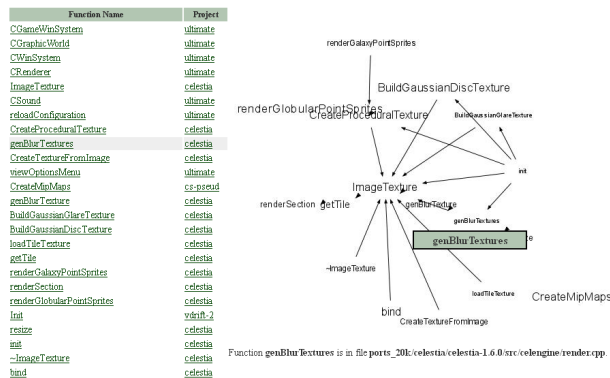
...



Building Prototypes

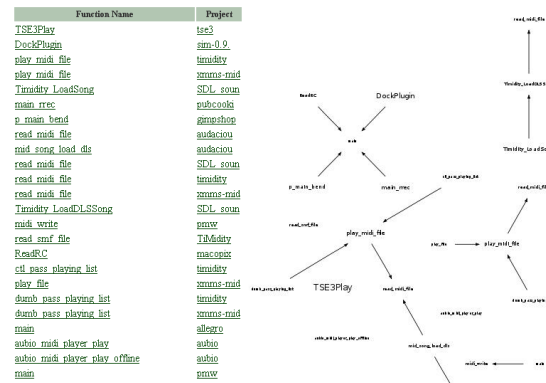
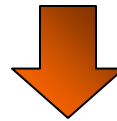
Feature 1

“download manager”



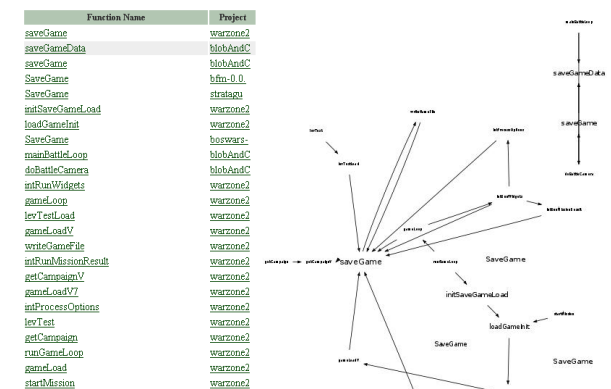
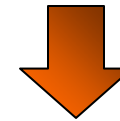
Feature 2

“search bar”



Feature 3

“tabbed browsing”



* C. McMillan, M. Grechanik, D. Poshyvanyk, Q. Xie, C. Fu, "Portfolio: Finding Relevant Functions And Their Usages", ICSE'11.

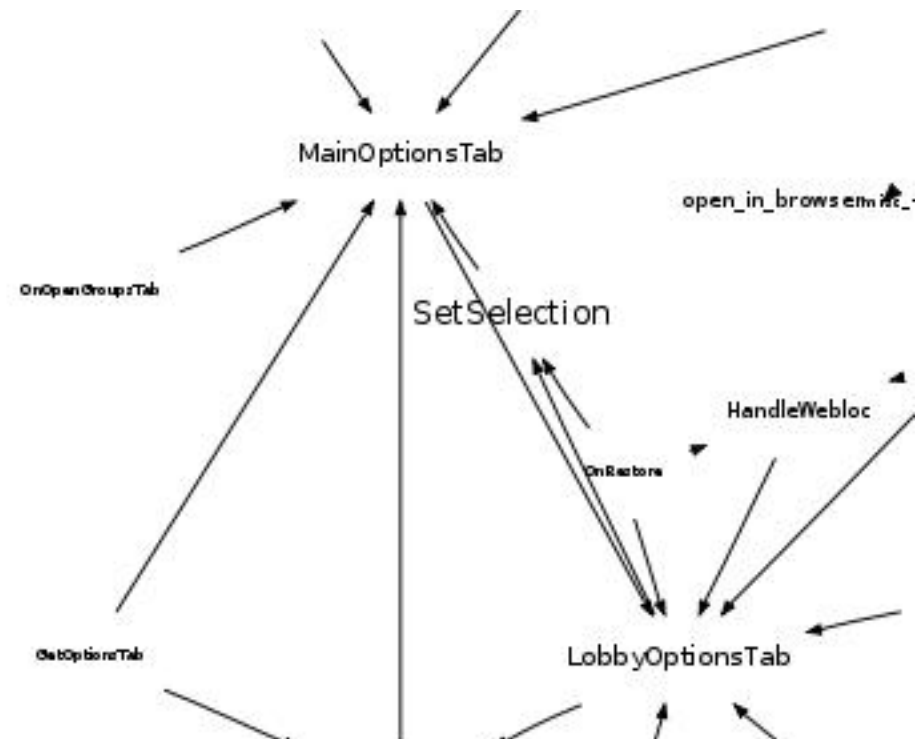
Feature 1

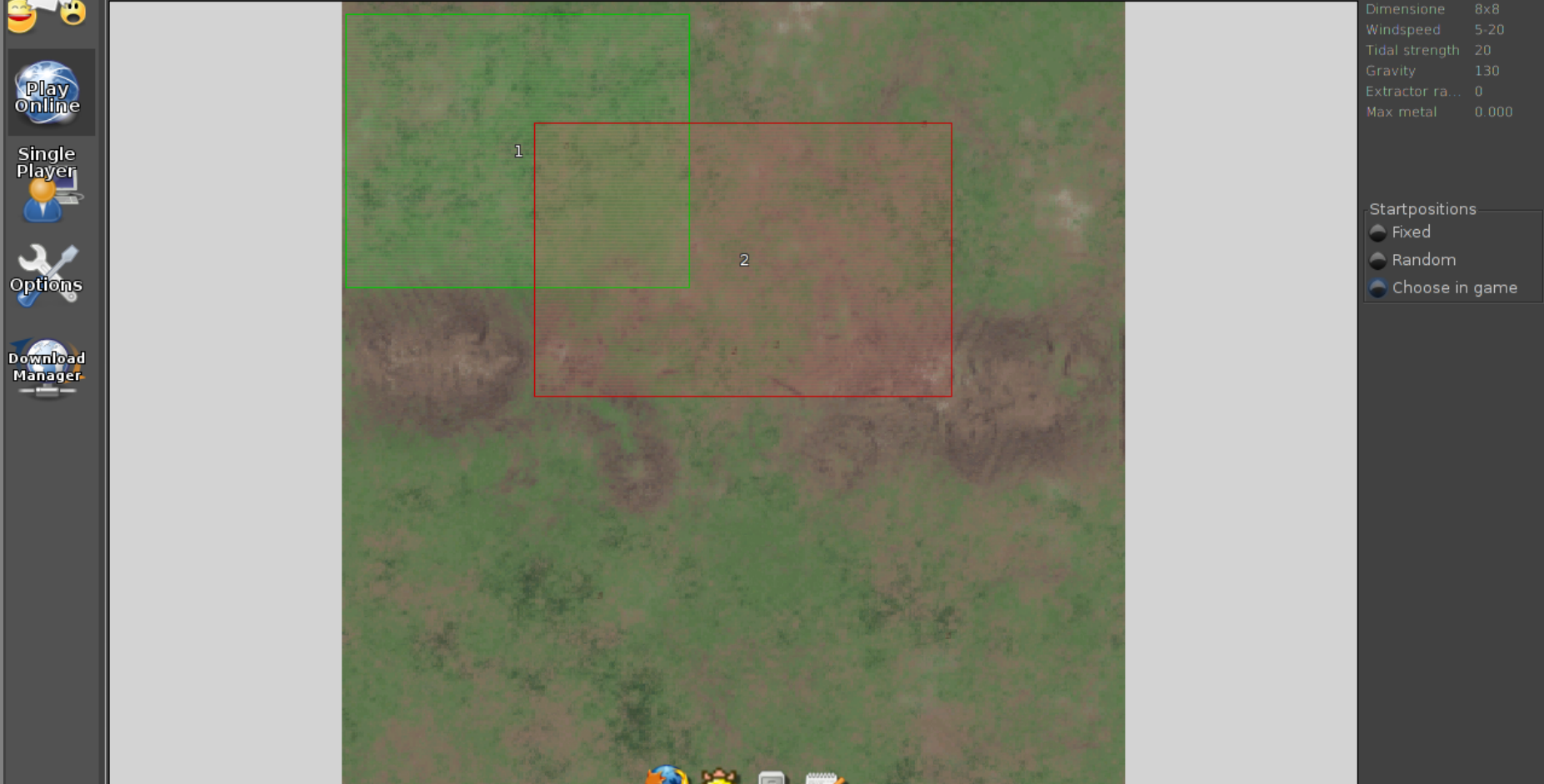
“download manager for web browser”



OnDefaultWeb
~LobbyOptionsTab
OnBrowseEditor
OnBrowseWeb
OnApply
~MainOptionsTab
OnOpenGroupsTab
GetOptionsTab
prefs helpers
browser open data file
selected ptree info answered cb
midori web settings class init
initialize items

springlo
springlo
springlo
springlo
springlo
springlo
springlo
springlo
xdvik
ethereal
ethereal
midori
xdvik





Dimensione 8x8
Windspeed 5-20
Tidal strength 20
Gravity 130
Extractor ra... 0
Max metal 0.000

Startpositions

- ☐ Fixed
- ☐ Random
- ☒ Choose in game

SmallDivide

Chat

Transfers in progress:

Name	numcopies	MB downloaded	MB uploaded	status	% complete	KB/s up	KB/s down	ETA (s)	Filesize (MB)
CoastToCoastRemakeV2.sd7	not available	0	0	seeding	100	0	0	inf. s	4.350
DeltaSiegeRevX.sd7	5.96899	49.8595	0	leeching	97.2726	0	341.722	12220 s	32.133
GreenCometBasic.sd7	7.98214	7.25	0	leeching	98.1913	0	25.5763	263 s	13.822
Islands_In_War_1.0.sd7	not available	0	0	seeding	100	0	0	inf. s	9.912
Tabula-v3(1).sd7	3.98913	6.25	0	leeching	98.9054	0	25.5605	664 s	22.840

Play Online

Single Player

Options

Download Manager

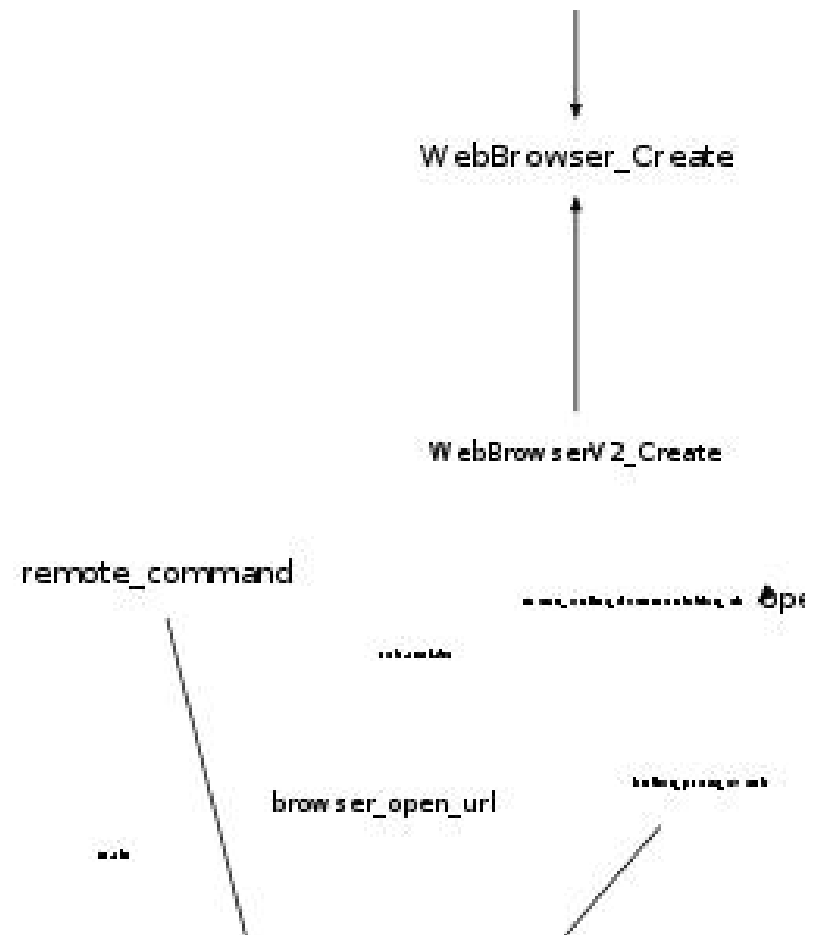
Total Outgoing: 0.18 KB/s Total Incoming: 393.45 KB/s Status: connected

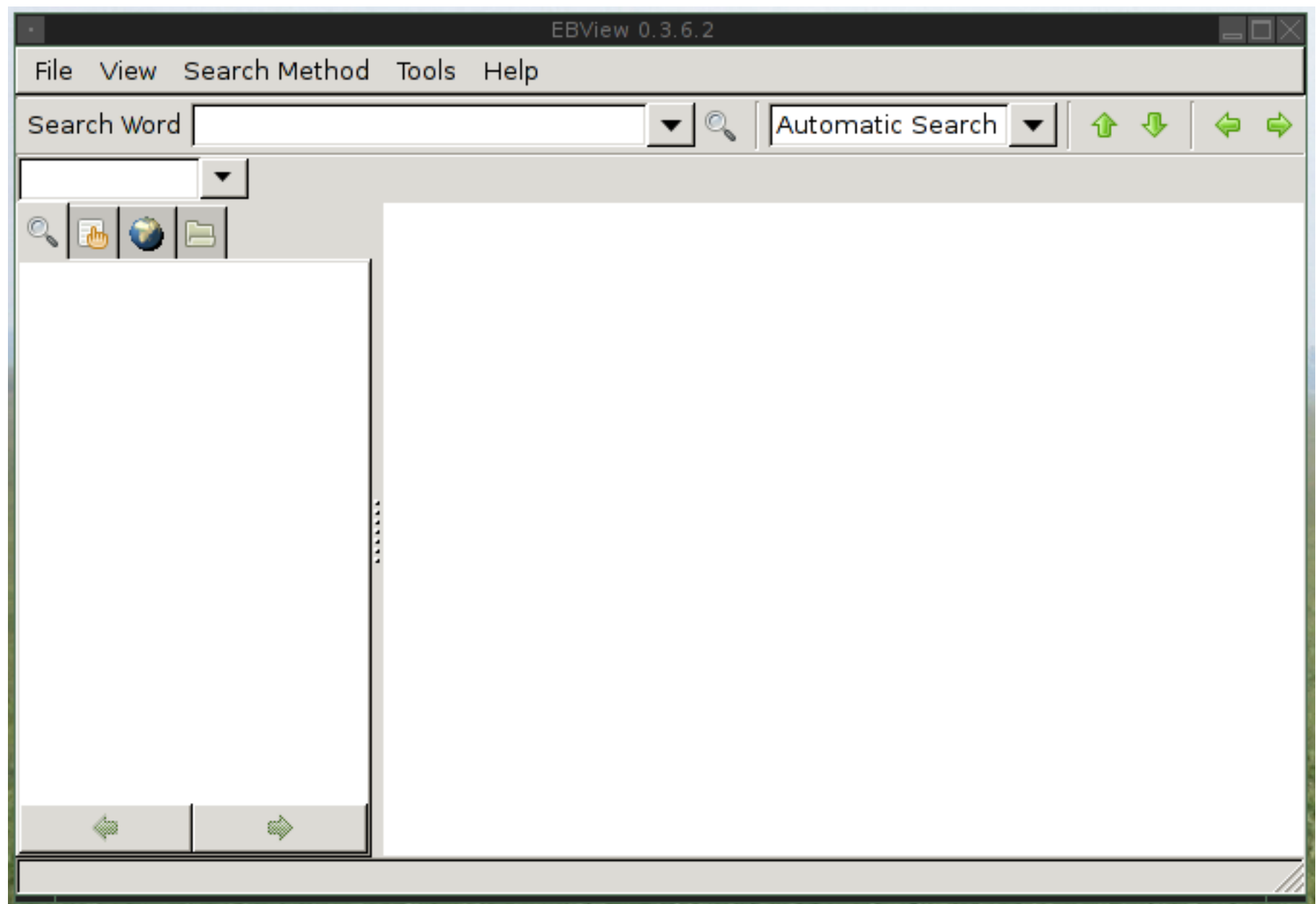
Cancel Download Publish new file Search file

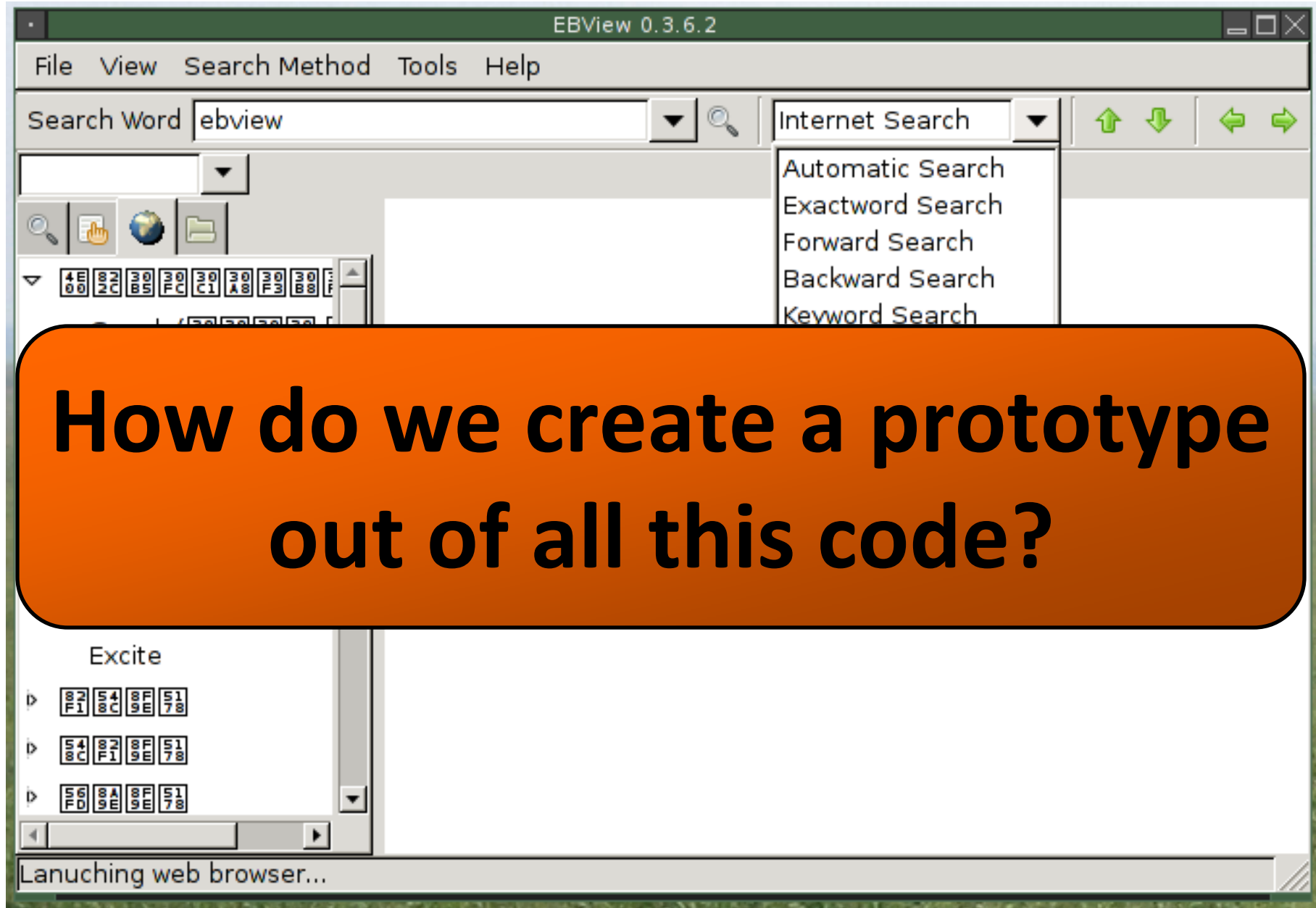
“web browser search bar”



[ebview](#)
[ebview](#)
[pureadmi](#)
[ebview](#)
[wine-1.0](#)
[wine-1.0](#)
[midori](#)
[kadu](#)
[pureadmi](#)
[kadu](#)
[kadu](#)
[gimp-2.4](#)
[gimpshop](#)
[ebview](#)



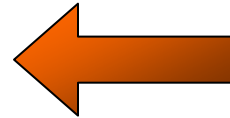




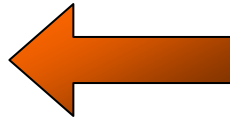
Source Code of Mozilla Firefox 8.0:

~/firefox/src/browser/components/

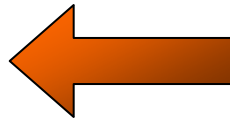
drwxr-xr-x	..
drwxr-xr-x	<u>aboutfiles</u>
drwxr-xr-x	<u>buildfiles</u>
drwxr-xr-x	<u>certerrorfiles</u>
drwxr-xr-x	<u>dirproviderfiles</u>
drwxr-xr-x	<u>downloadsfiles</u>
drwxr-xr-x	<u>feedsfiles</u>
drwxr-xr-x	<u>migrationfiles</u>
drwxr-xr-x	<u>placesfiles</u>
drwxr-xr-x	<u>preferencesfiles</u>
drwxr-xr-x	<u>privatebrowsingfiles</u>
drwxr-xr-x	<u>safebrowsingfiles</u>
drwxr-xr-x	<u>searchfiles</u>
drwxr-xr-x	<u>sessionstorefiles</u>
drwxr-xr-x	<u>shellfiles</u>
drwxr-xr-x	<u>sidebarfiles</u>
drwxr-xr-x	<u>tabviewfiles</u>
drwxr-xr-x	<u>testfiles</u>
drwxr-xr-x	<u>thumbnailsfiles</u>



Feature 1
“download manager”



Feature 2
“search bar”



Feature 3
“tabbed browsing”

browser/components/downloads/src/DownloadsCommon.jsm

```
const Cc = Components.classes;
const Ci = Components.interfaces;
const Cu = Components.utils;
const Cr = Components.results;

Cu.import("resource://gre/modules/XPCOMUtils.jsm");
Cu.import("resource://gre/modules/Services.jsm");

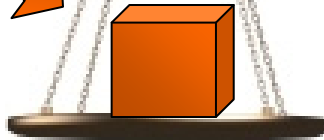
XPCOMUtils.defineLazyServiceGetter(this, "gBrowserGlue",
                                   "@mozilla.org/browser/browserglue;1",
                                   "nsIBrowserGlue");
```

Highly coupled to other code.

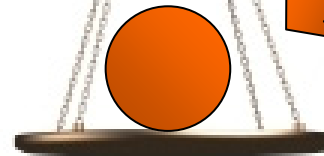
```
sizeWithUnits: true,  
shortTimeLeftSeconds: true,  
shortTimeLeftMinutes: true,  
shortTimeLeftHours: true,  
shortTimeLeftDays: true,  
statusSeparator: true,  
statusSeparatorBeforeNumber: true,  
fileExecutableSecurityWarning: true  
};  
  
XPCOMUtils.defineLazyGetter(this, "DownloadsLocalFileCtor", function () {  
    return Components.Constructor("@mozilla.org/file/local;1",  
        "nsILocalFile", "initWithPath");  
});
```

Two Competing Goals

**Domain
Relevance**



**Low
Coupling**



MIDI music player for a small Java game. The music must play in the background and not interfere with the game play.

Submit



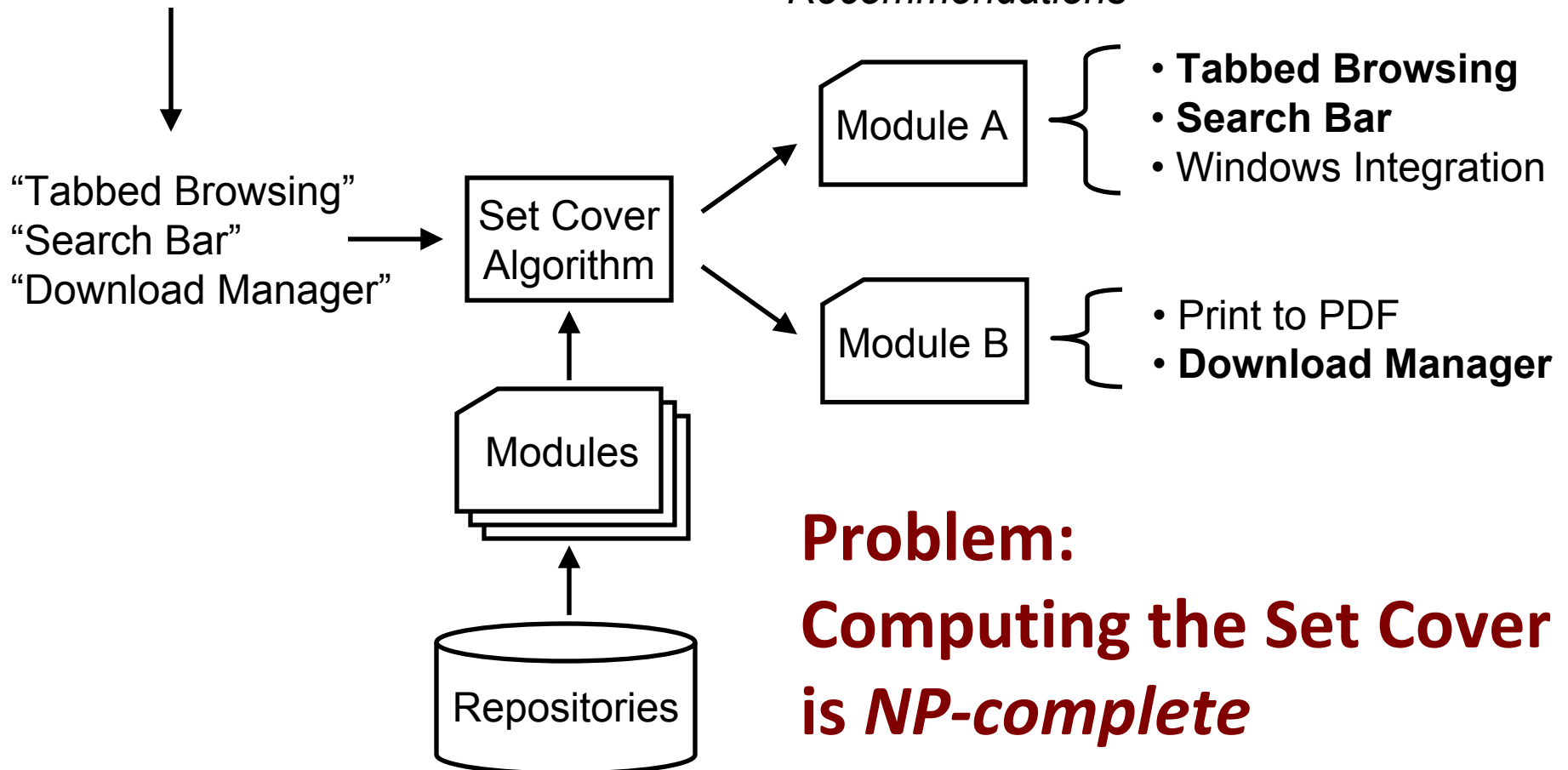
	ID	Feature
☒	28	Music plays in the background
☒	140	Sound supported.

	ID	Feature
☒	765	Support for MP3, WAV, MIDI
☒	741	MIDI Learn for every parameter
☒	744	Volume Normalization

Project Name	Features	Package ID	Package Name
vyger	765, 28, 744	46152	wotlas.libs.sound - MusicResourceLocator - SoundLibrary - SoundResourceLocator - SoundPlayer - JavaMidiMusicPlayer
wisl	140	185732	info.wisl
orbas	741	92092	org.huihoo.orbas.rutil.threadpool

Graphic RPG MUD with Java.
Maps with 2d Tiles;
Editor to draw tile maps;
Adding spells (such Time Stop etc);

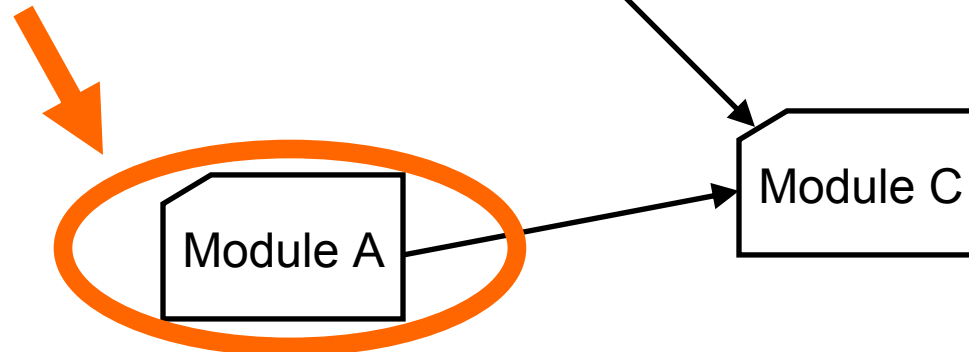
Our Solution: Set Coverage of Features

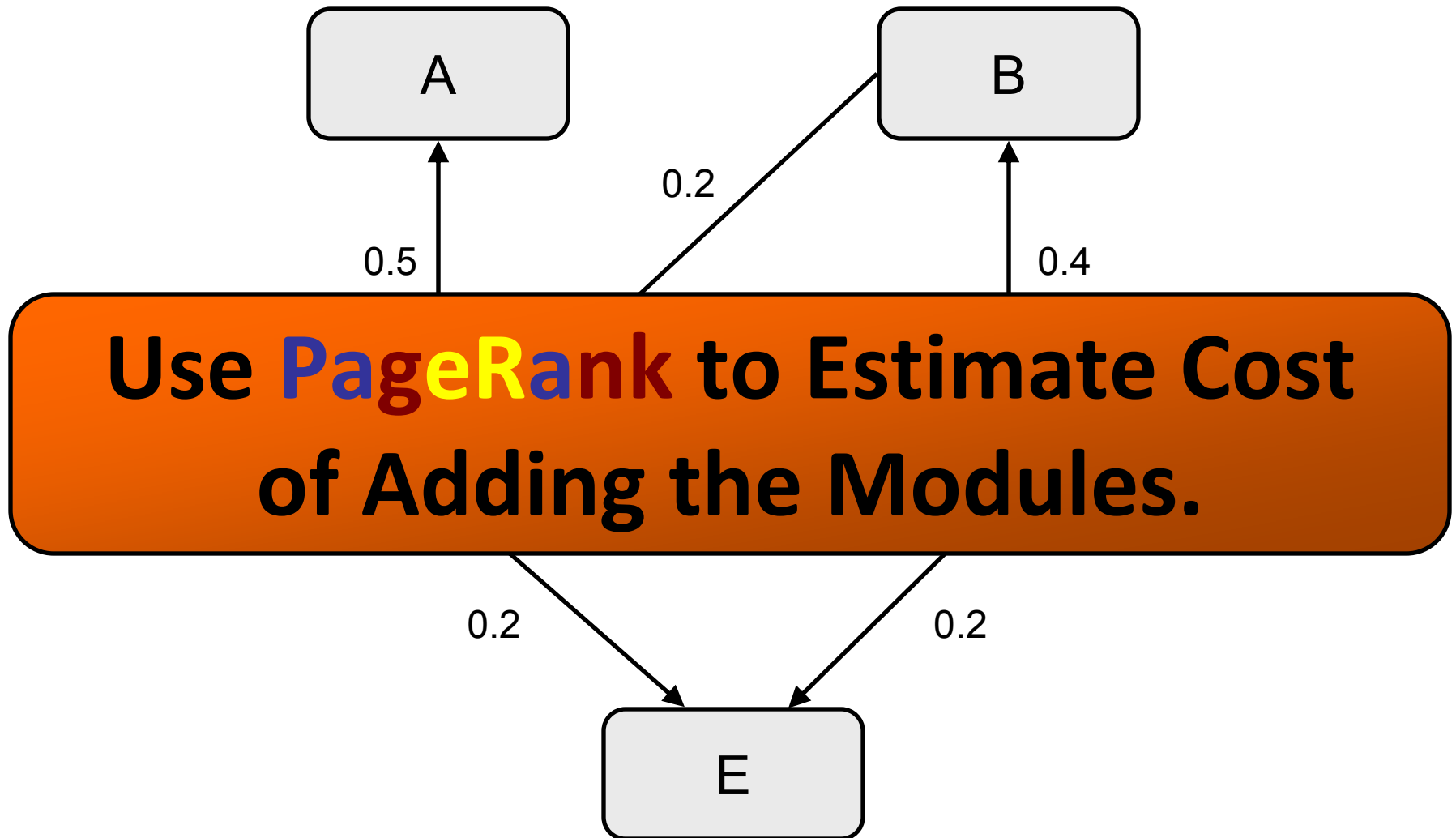


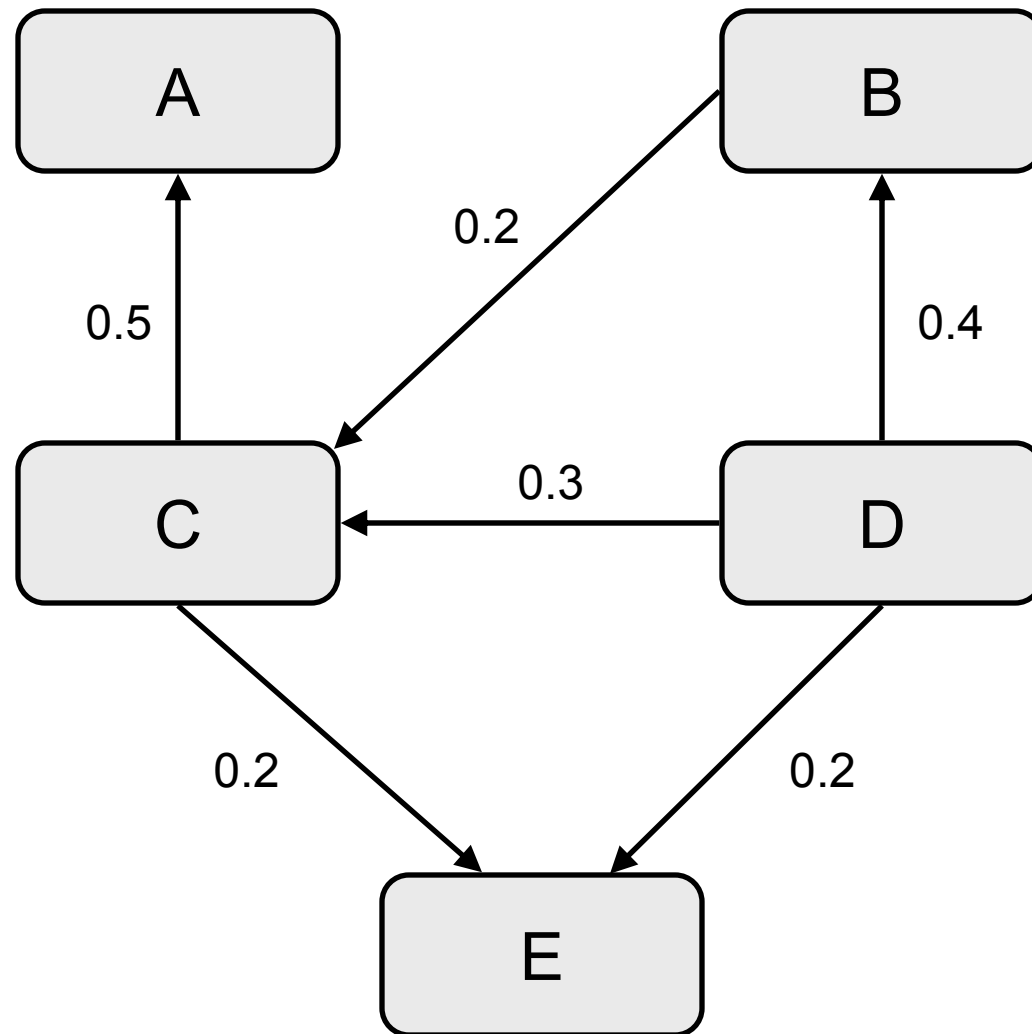
Set Coverage: Our Approximation

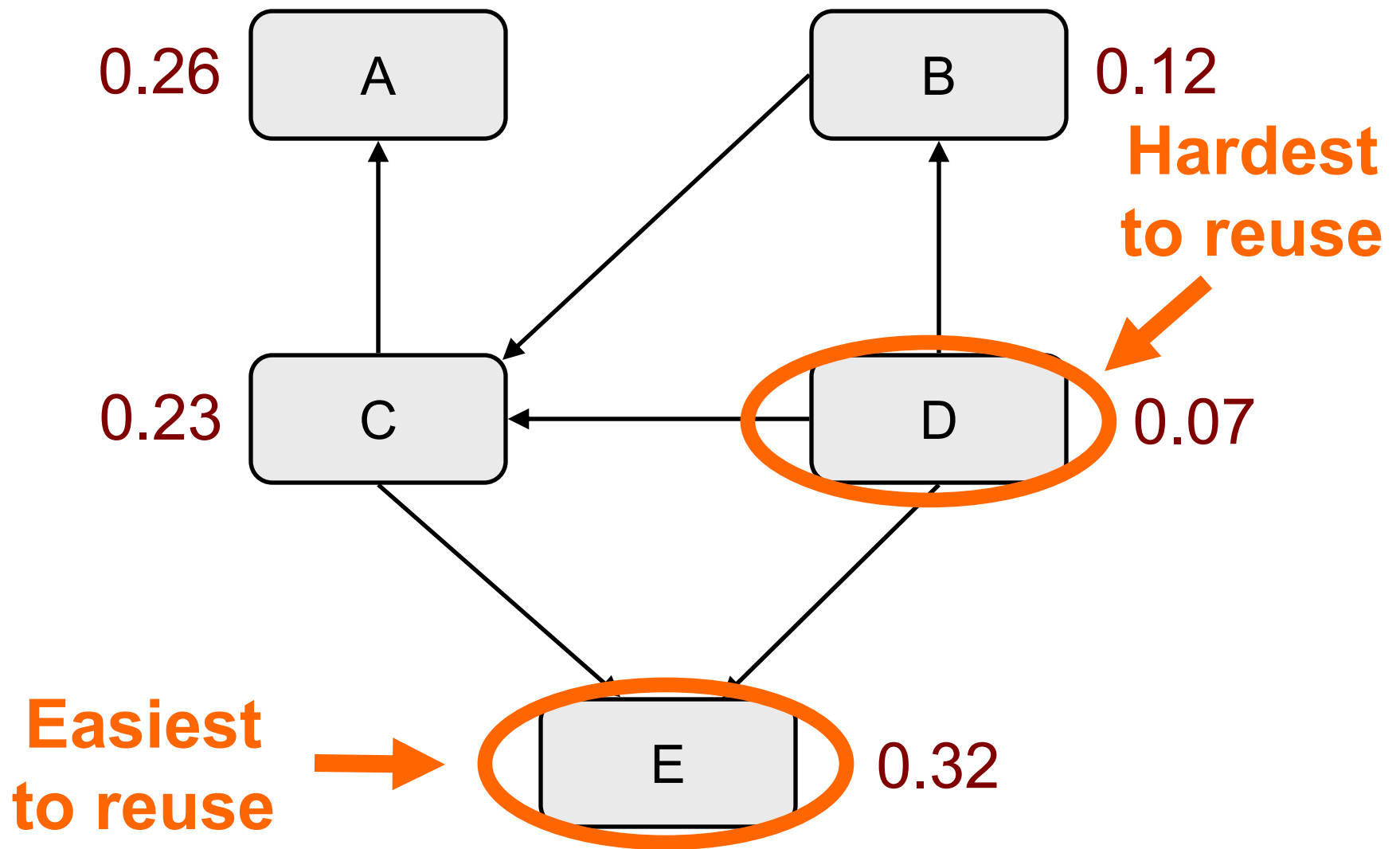
- **Greedy** Approximation to Set Coverage
- Choose the module that is **least-expensive** to add
- Based on **Coupling Between Objects (CBO)**

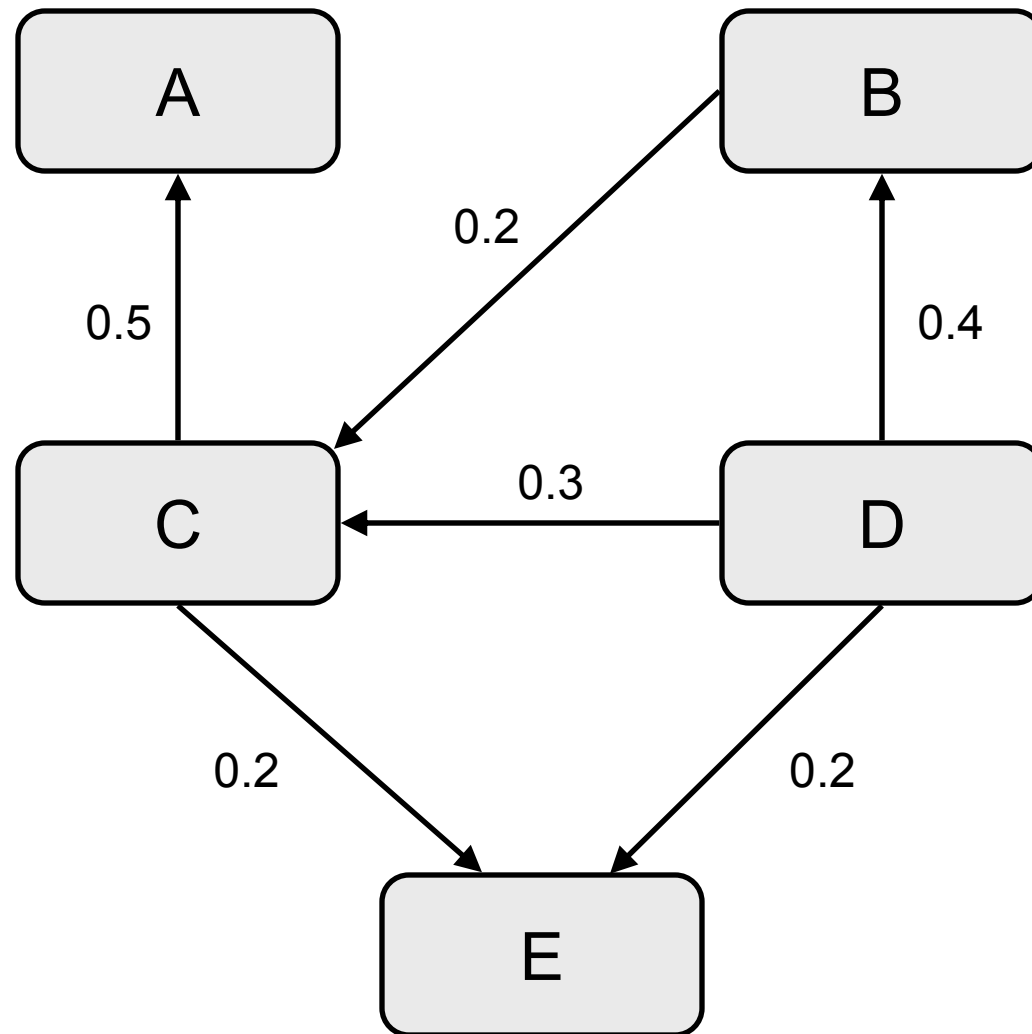
Module A is less
coupled than
Module B or
Module B?

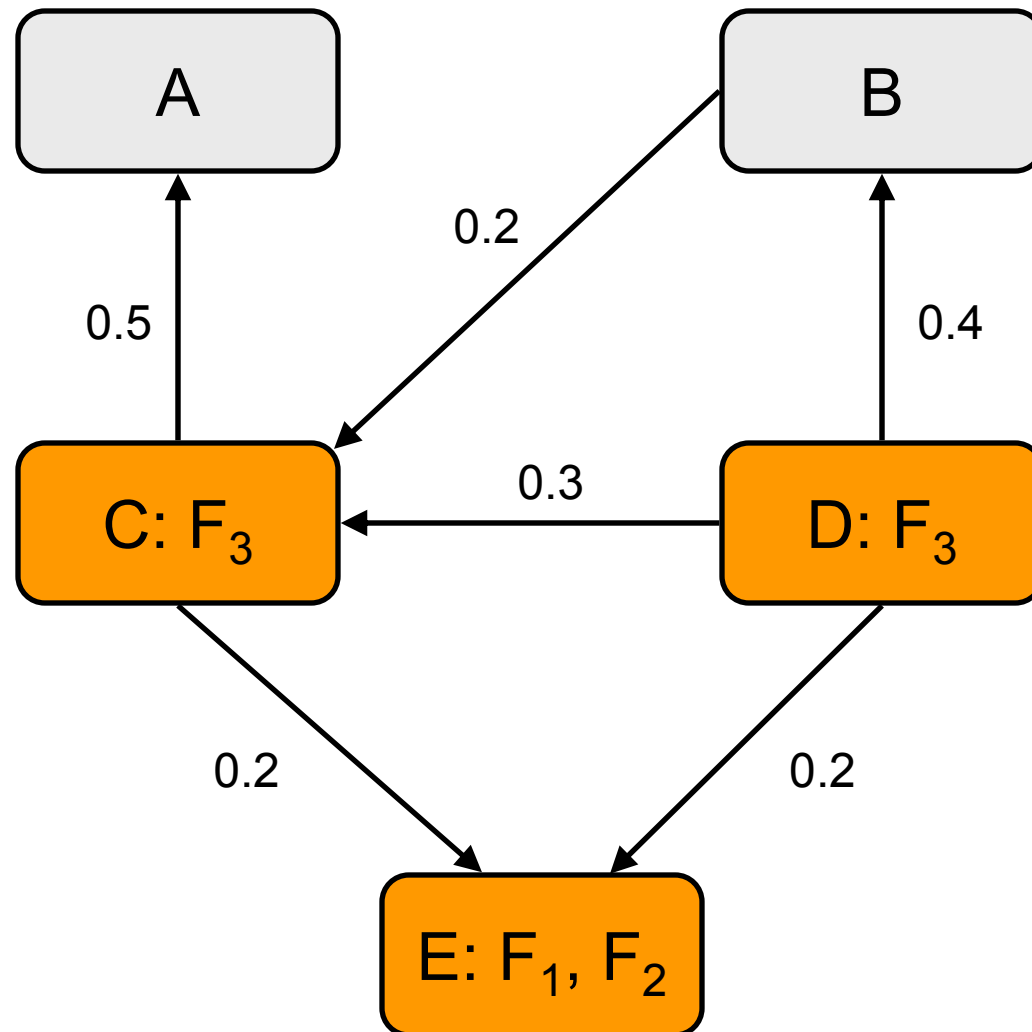


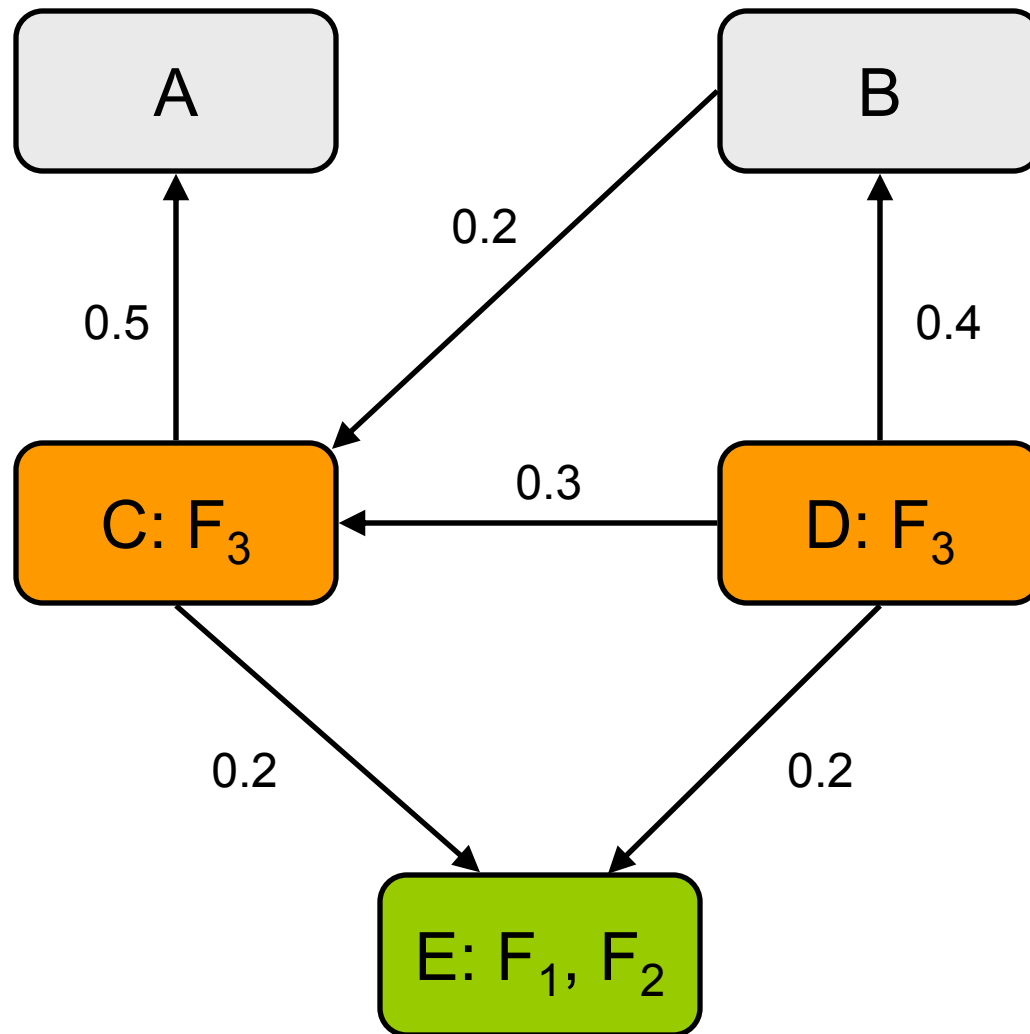


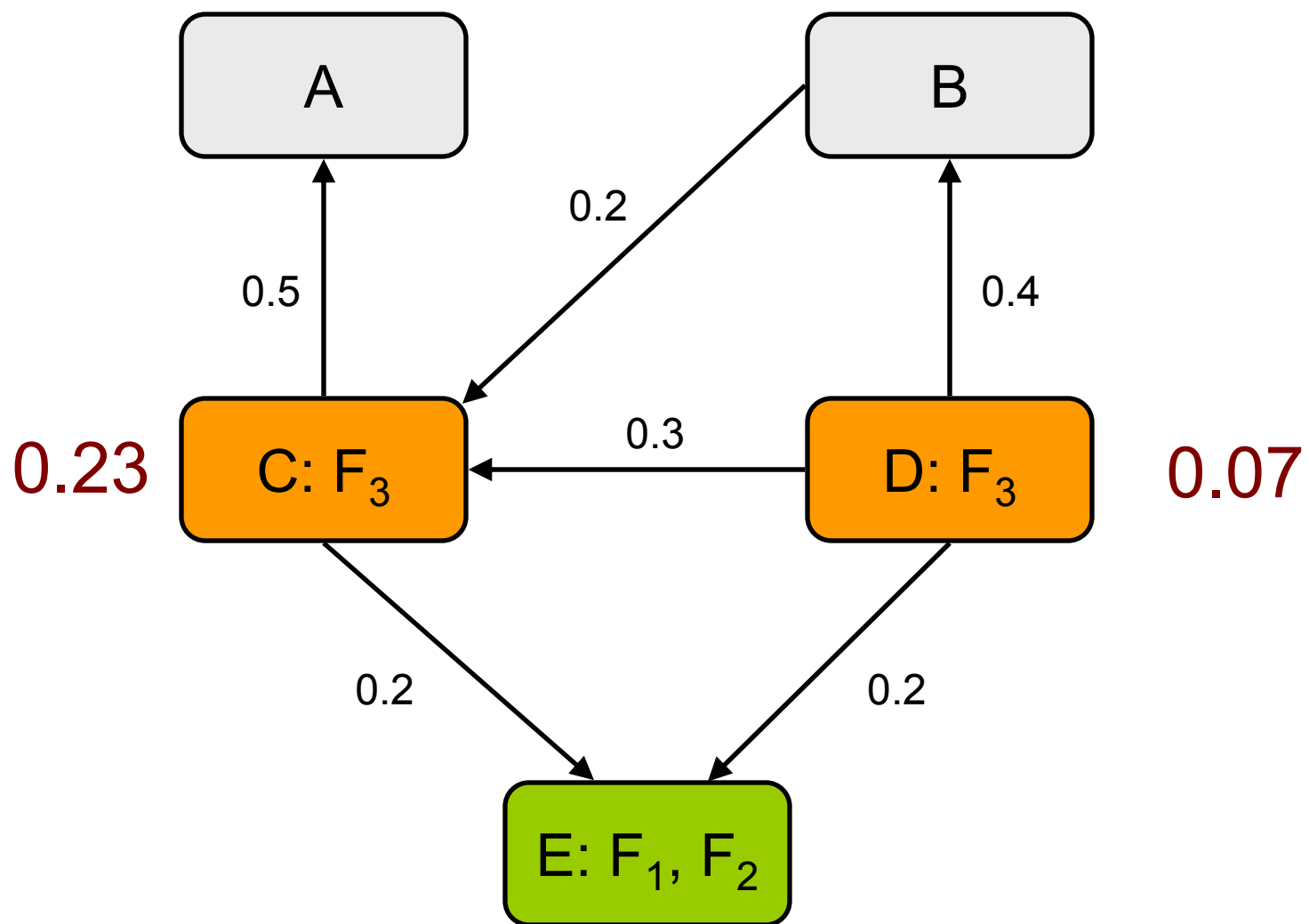


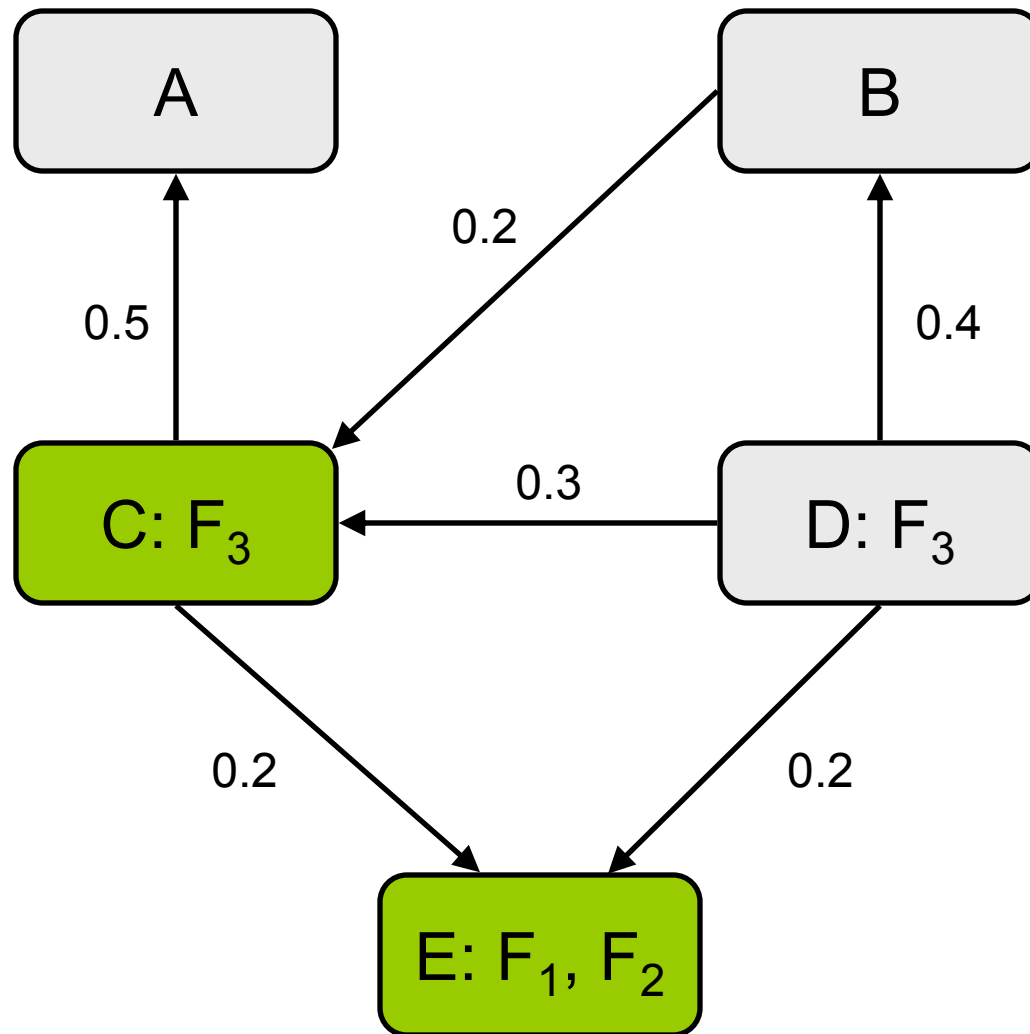


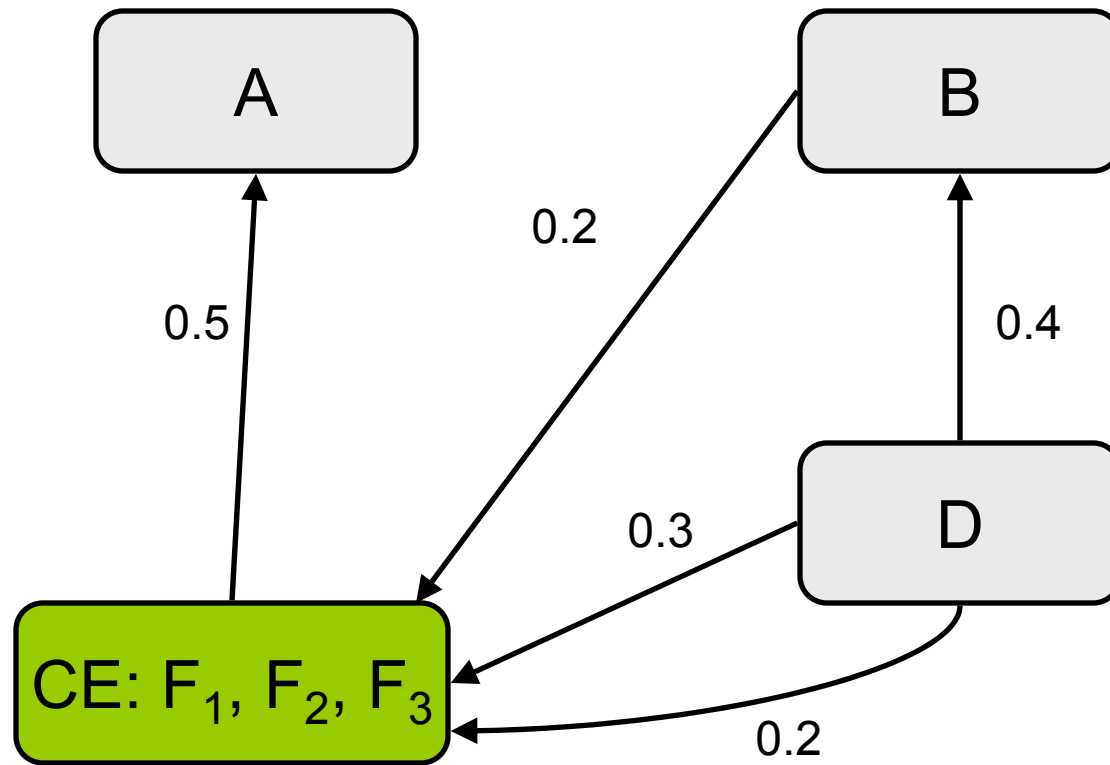


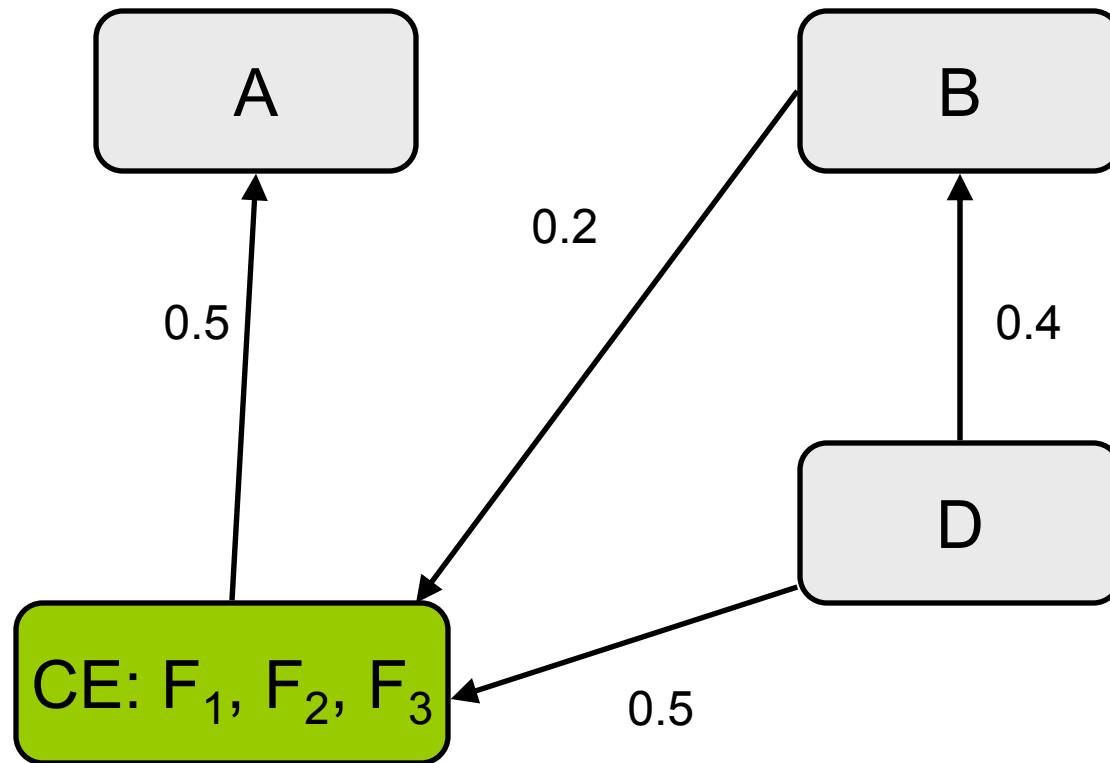


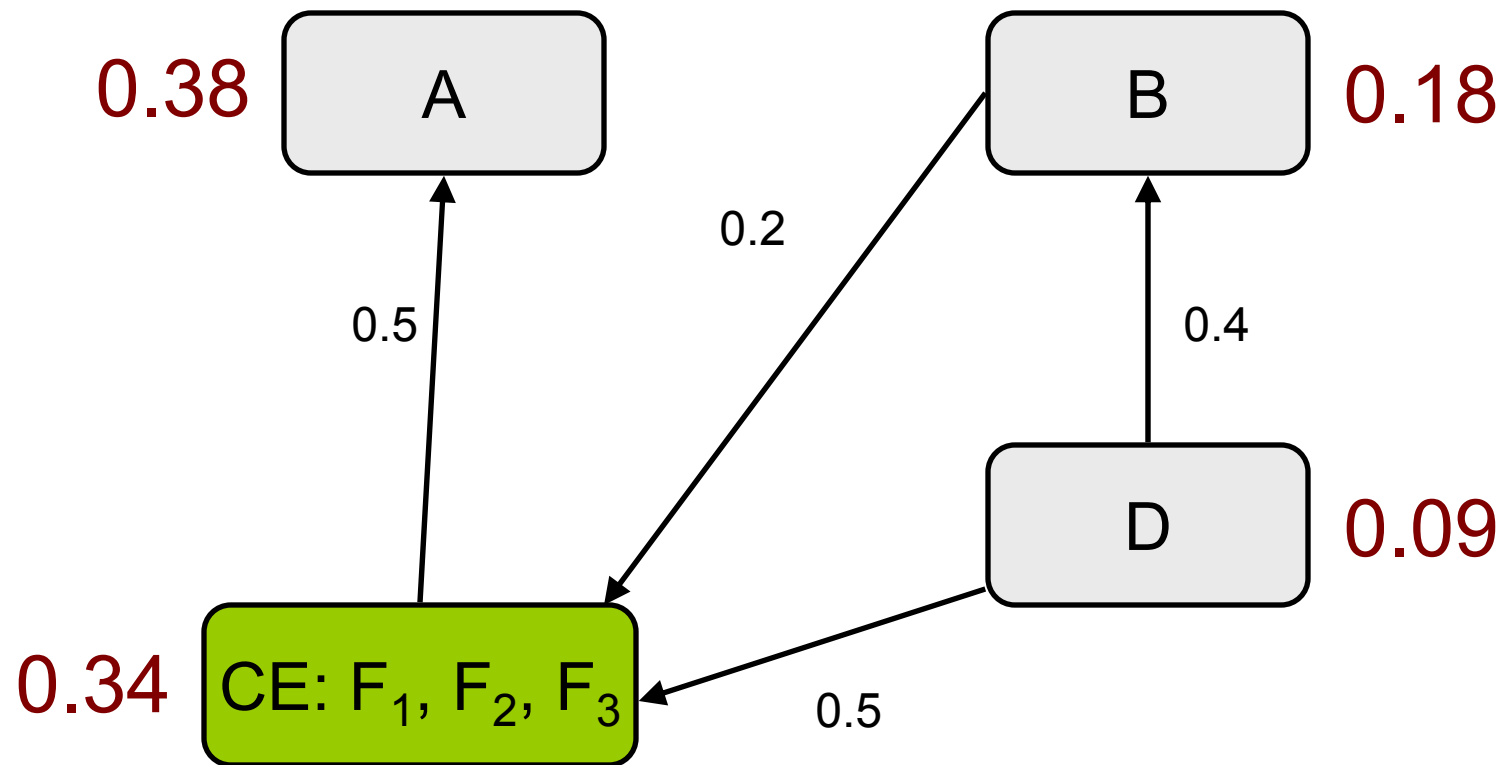






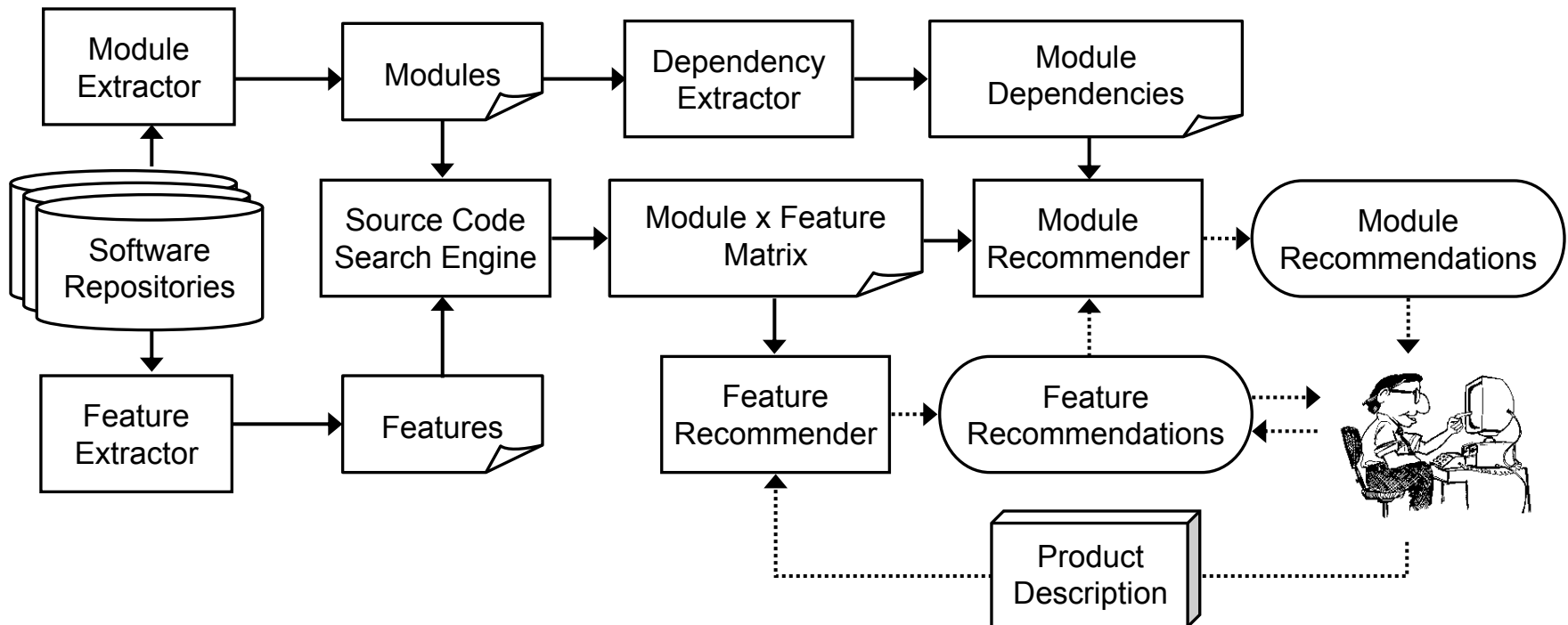






**Continue grouping nodes
until all features are covered...**

Putting it all together



Software Archive

Modules from Sourceforge / Merobase¹

- **241,655 Java packages**
- 13,701 Java projects
- 440 Million Total Lines of Code

Features from Softpedia

- **1,135 Features**
- 493,347 Feature Descriptions

¹ O. Hummel, W. Janjic, C. Atkinson, “*Code Conjuror: Pulling Reusable Software out of Thin Air*”, IEEE Software, 2008.

Evaluation – User Study

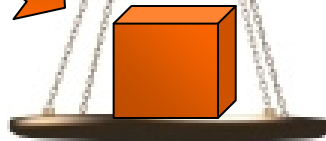
To compare **Prefab** with **Portfolio**, a state-of-the-art source code search engine.

31 Java Programmers participated

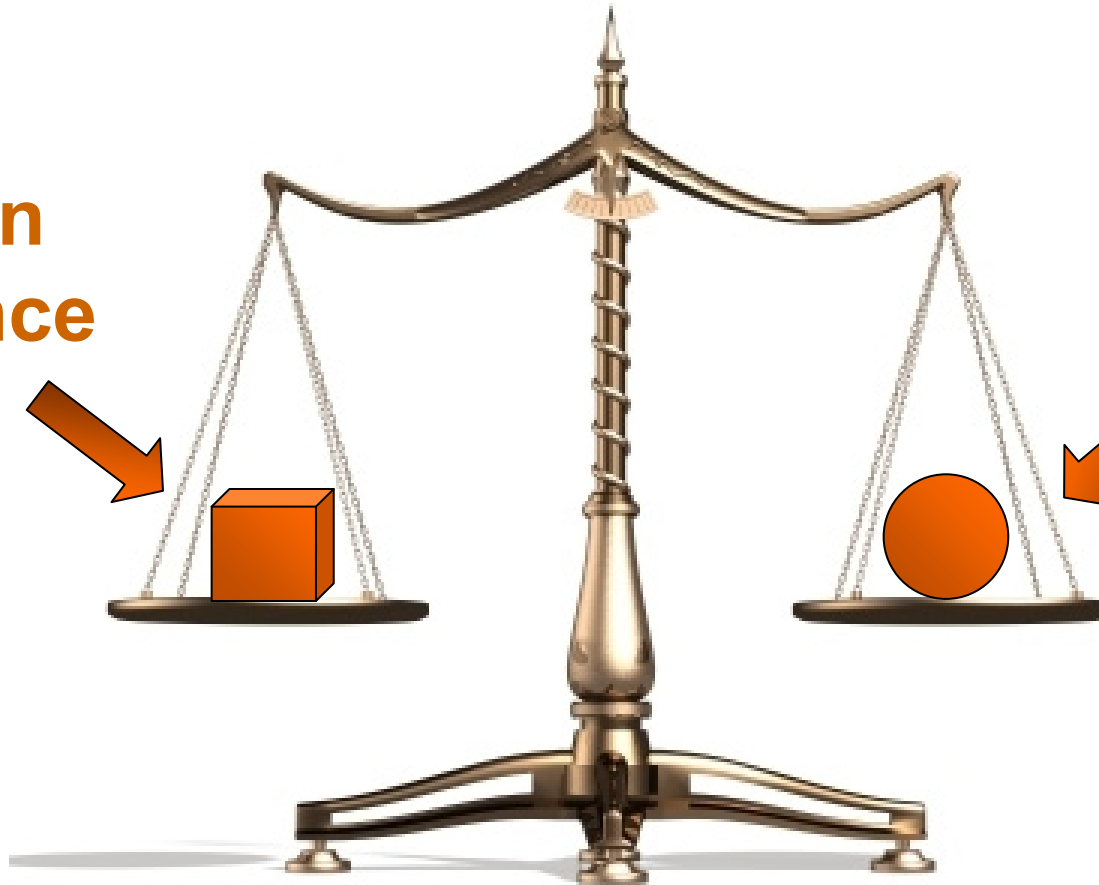
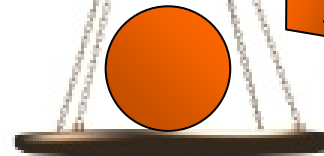
- Students at William & Mary
- 14 had professional experience
- Average 4.8 years of programming knowledge

Remember our Goals

**Domain
Relevance**



**Low
Coupling**



State-of-the-art Search Engines

**Domain
Relevance**



**Low
Coupling**

State-of-the-art Search Engines

Feature 1

“download manager”

Feature 2

“search bar”

Feature 3

“tabbed browsing”

Type in your search terms to begin

All Languages ▾

All Licenses ▾

?

Search



What do we type here?

Step 1

Enter a description of the product.

MIDI music player for a small Java game. The music must play in the background and not interfere with the game play.

Submit

Step 2

*Select **features** relevant to the query.*

	ID	Feature
☒	28	Music plays in the background
☒	140	Sound supported.

	ID	Feature
☒	765	Support for MP3, WAV, MIDI
☒	741	MIDI Learn for every parameter
☒	744	Volume Normalization

Step 3

Determine which features are implemented in each module.

Project Name	Features	Package ID	Package Name
vyger	765, 28, 744	4615	wotlas.libs.sound - MusicResourceLocator - SoundLibrary - SoundResourceLocator - SoundPlayer - JavaMidiMusicPlayer
wisl	140	185732	info.wisl
orbas	741	92092	org.huihoo.orbas.rutil.threadpool

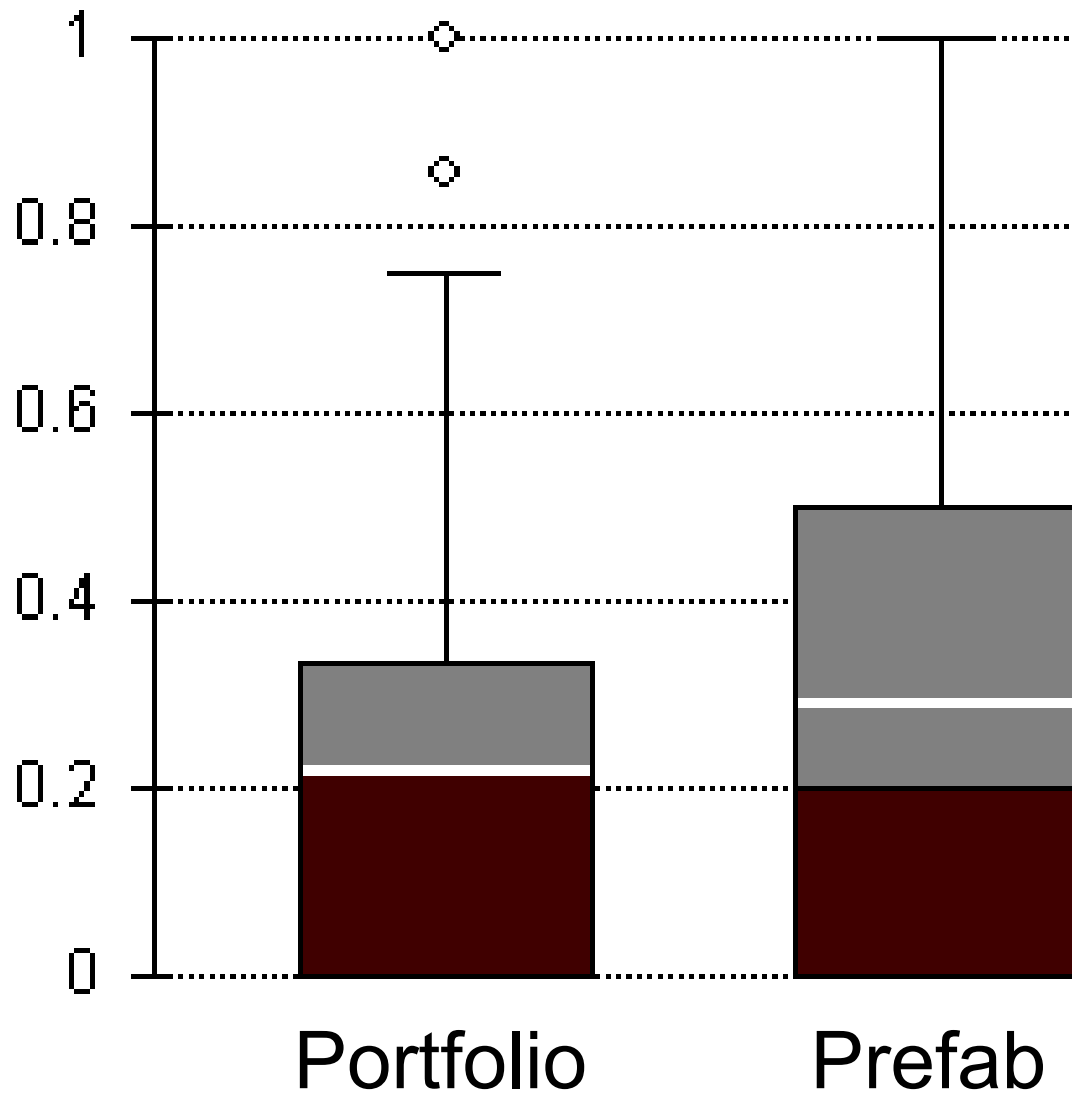
Graphic RPG MOD with 2D tiles;
Maps with 2d Tiles;
Editor to draw tile maps;
Adding spells (such Time Stop etc);

Participants evaluate
which **packages** implement
which **features**.

Cross-Validation Design

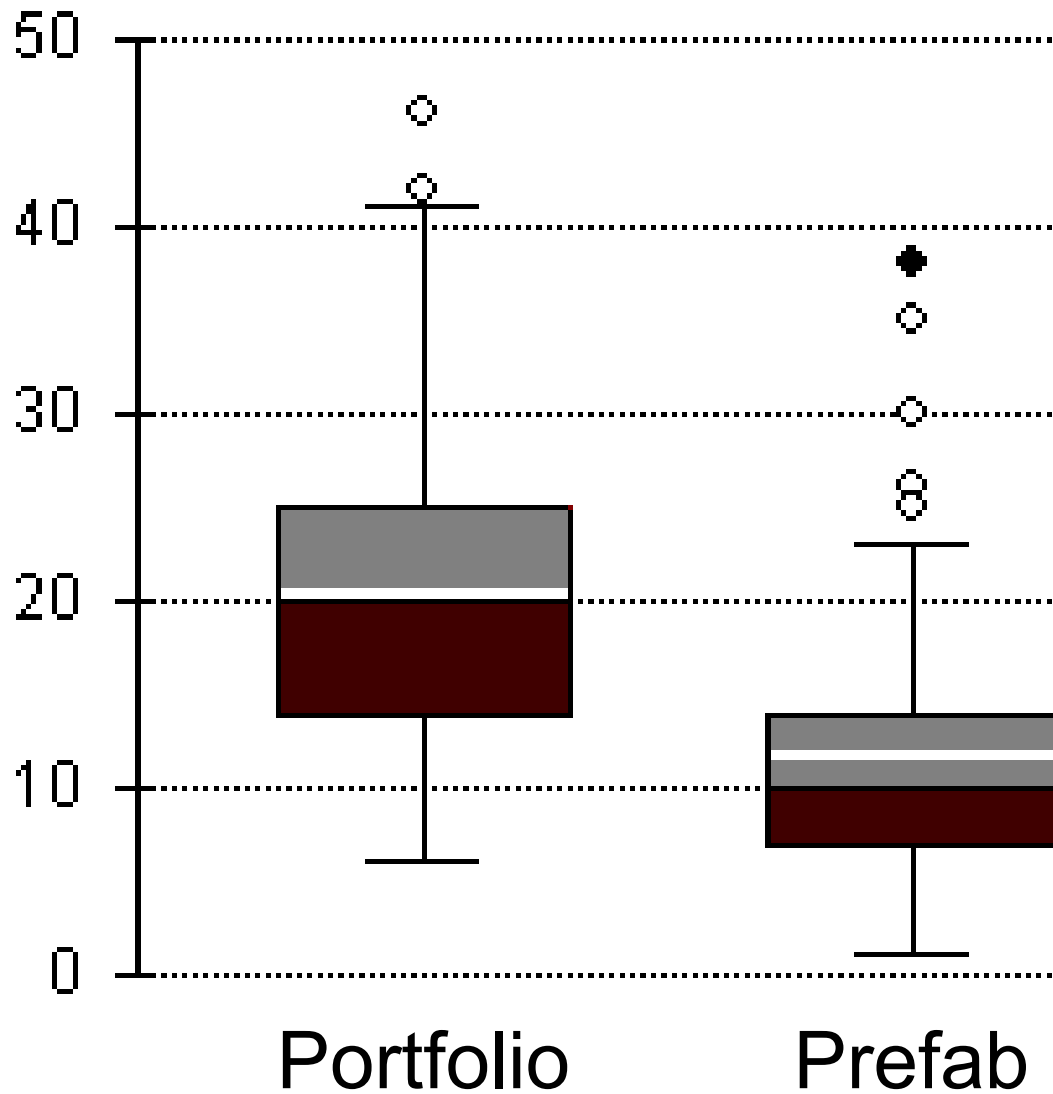
Experiment	Group	Approach	Task Set
1	A	Portfolio	T1
	B	Prefab	T2
2	A	Prefab	T3
	B	Portfolio	T4

Features Covered Per Package



p	$2 \cdot 10^{-4}$
F	13.4
F _{crit}	3.85

Time Per Query (in Minutes)



p	$2 \cdot 10^{-10}$
F	46.5
F _{crit}	3.90

Conclusions

- Recommend source code **modules** that implement a **set of features**
- Combines two state-of-the-art approaches
- Evaluated in a **user study** with 31 programmers
- All data online:

<http://www.cs.wm.edu/semeru/prefab/>

