Shake: A Better Make

Neil Mitchell, Standard Chartered

Haskell Implementors Workshop 2010

Question

Do you like your Make system?

- Make system builds multi-language stuff
  - Not ghc --make, cabal install, Visual Studio

An Example

```
import Development.Shake
main = shake $ do
  want ["Main.exe"]
  "Main.exe" *> \x -> do
      cs <- ls "*.c"
      let os = map (`replaceExtension` "obj") cs
      need os
      system $ ["gcc","-o",x] ++ os
  "*.obj" *> \x -> do
      let c = replaceExtension x "c"
      need [c]
      need =<< cIncludes c
      system ["gcc","-c",c,"-o",x]
```

Benefits of Shake

- A Haskell library for writing build systems
  - Can use modules/functions for abstraction/separation
  - Can use Haskell libraries (i.e. filepath)
- It’s got the useful bits from Make
  - Automatic parallelism
  - Minimal rebuilds
- But it’s better!
  - More accurate dependencies (i.e. the results of ls are tracked)
  - Can produce profiling reports (what took most time to build)
  - Can deal with generated files properly
  - Properly cross-platform

Quick Tour

```
shake :: Shake () -> IO ()

want :: [FilePath] -> Shake ()
(*>) :: String -> (FilePath -> Act ()) -> Shake ()

need :: [FilePath] -> Act ()
system :: [String] -> Act ()
ls :: String -> Act [FilePath]
```

Sugar Functions

```
readFileLines :: FilePath -> Act [String]
readFileLines x = do
  need [x]
  liftIO $ fmap lines $ readFile x

copy :: FilePath -> FilePath -> Act()
copy from to = do
  mkdir $ takeDirectory to
  need [from]
  system' ["cp",quote from,quote to]
```

The Oracle

- The Oracle is used for non-file dependencies
  - What is the version of GHC? 6.12.3
  - What extra flags do we want? --Wall
  - `ls` is a sugar function for the Oracle

```
type Question = (String,String)
type Answer = [String]
oracle :: (Question -> Answer) -> Shake a -> Shake a
query :: Question -> Act Answer
```

The Generated File Problem

- Make has a problem with generated files (i.e. .hsc files)

```
$ cat Foo.c
#include <MyGeneratedFile.h>
```

- What are the dependencies of Foo.c?
  - Use the Make system to generate MyGeneratedFile.h
  - Read the contents of MyGeneratedFile.h for #include’s
- Faking it in Make
  - Run make twice (or more), first to generate files
  - Guess at the dependencies in advance

The Implementation

NO DEPENDENCY GRAPH!

History Traces

- A history trace is a list of question/answer pairs
  - What is the timestamp of Foo.c? 10am
  - What is the result of ls “*.c”? ["Foo.c"]
- When building a file, record the history
- Save that history to disk
- File is dirty if any answer has changed
- Alternatively: history is an abstract interpretation of a rule

```
type History = [QA]
data QA = Oracle Question Answer
        | Need [(FilePath,ModTime)]
```

Implementation of need

```
type Database = Map FilePath Status
data Status = Dirty History
            | Clean History ModTime
```

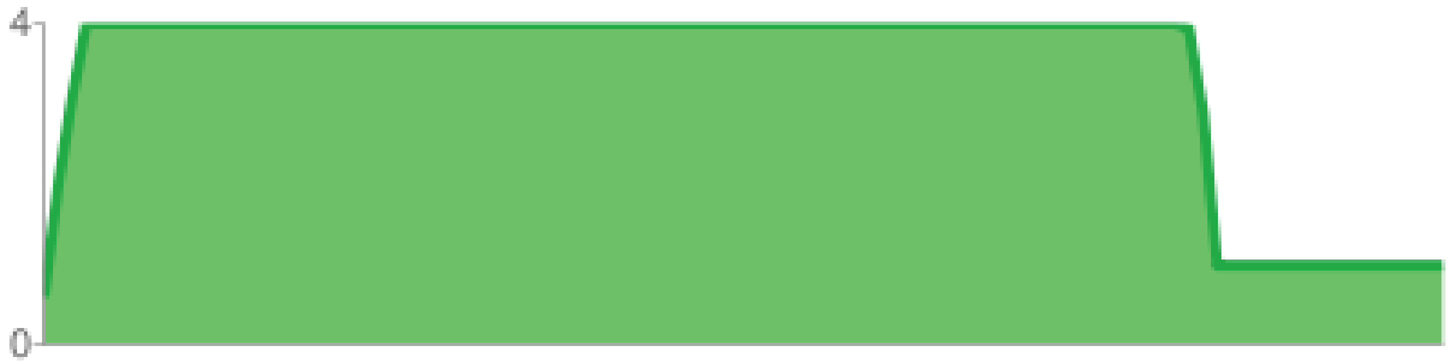
- Every Act accumulates a history
- In need:
  - Make sure the file is Clean
  - Add file/time to Act's history
- If Dirty, rerun history, and if matching
  - Get file's ModTime and switch to Clean
- If absent, or Dirty and history differs
  - If there is a matching rule, run it
  - If no rule but a real file, get it's ModTime

Parallelisation

- need/want both take lists of files, which run in parallel
- Try and build N rules in parallel
  - Done using a pool of N threads and a work queue
  - need/want put their jobs in the queue
- Add a `Building (MVar ())` in DataBase
- Shake uses a *random* queue
  - Jobs are serviced at random, *not* in any fair order
  - link = disk bound, compile = CPU bound
- Shake is highly parallel (in theory and practice)

Profiling

- Can record every system command run, and produce:



Average was 3.42 (interquartiles were 4.00 and 4.00)

Hot Tools

7.7s	🟩	7 × gcc

Hot Commands

1.8s	🟩	gcc -c file3.c -o file3.obj
1.8s	🟩	gcc -c file2.c -o file2.obj

Future work: Shake --lint

- Parallel building often shows up build rule errors
  - In practice using a random queue makes these show up fast
- I want shake --lint, run once, in serial, guarantee parallel consistency
  - Can check the access times on all files
  - Check no files not in the history were accessed
  - Check all files in the history were accessed

Future work: also files

- Also files are annoying!
  - GHC builds .o files and .hi files in one command
  - Some things depend on the .o, some on the .hi
  - One rule modifies 2 database entries!

```
type Rule = FilePath
          -> Maybe ([FilePath], Act ())
```

- Works, but impacts on lots of the core code
  - Not really a good model for also files
  - Potential for inconsistency

Practical Use

- Relied on by an international team of people every day
- Building more than a million lines of code in many languages

- Before Shake
  - Masses of really complex Makefiles, slow builds
  - Answer to any build error was “make clean”

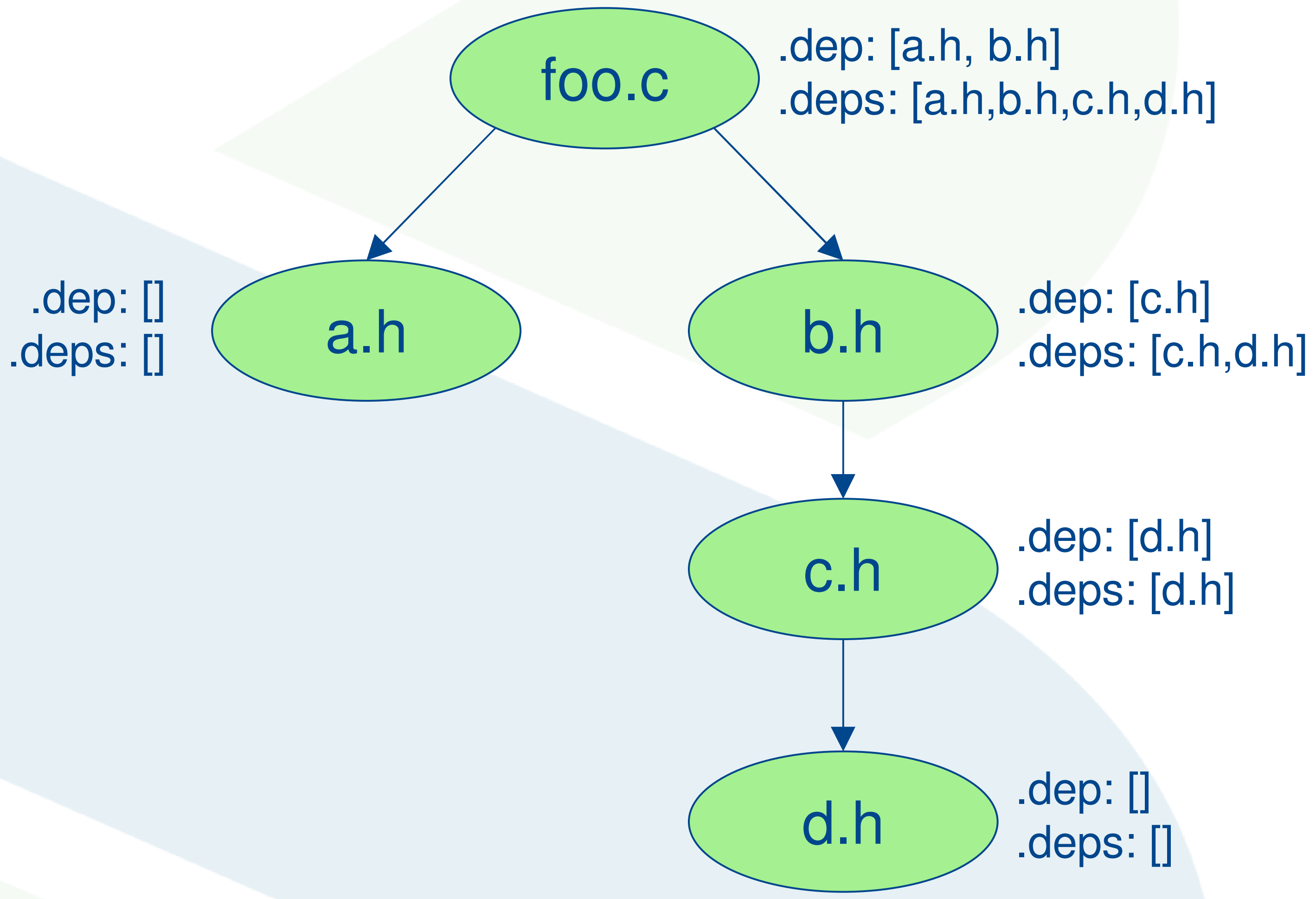
- After Shake
  - Robust and fast builds (at least x2 faster)
  - Maintainable and extendable (at least x10 shorter)

Limitations/Disadvantages

- Creates a _database file to save the database
- Oracle is currently “untyped” (String’s only)
  - Although easy to add nicely typed wrappers over it
- Massive space leak (~ 12% productivity)
  - In practice doesn’t really matter, and should be easy to fix
- More dependency analysis tools would be nice
  - Changing which file will cause most rebuilding?
- What if the rules change?
  - Can depend on Makefile.hs, but too imprecise

- Not currently open source

Transitive Dependencies (theory)



Transitive Dependencies (Shake)

```
"*.c.dep" & "*.h.dep" *> \x -> do
  src <- readFileLines $ dropExtension x
  writeFileLines x
    [drop 8 s | s <- lines src, "#include"
  `isPrefixOf` s]

"*.deps" *> \x -> do
   incs <- readFileLines $ replaceExtension x
  "dep"
   let incs2 = map (<.> "deps") incs
   need incs2 -- parallel optimisation
   writeFileLines x =<< concatMapM readFileLines
  incs2
```

Conclusions

- Haskell is a great language for a DSL
- A Make system is a DSL

- Any Make system based on a static dependency graph will fail to work with generated files
- Accurate dependency tracking is essential (i.e. Oracle)

- Shake is a Make system people actually *like*!