

Embedded Software Essentials

Make

C1 M2 V6

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Building Manually [S1a]


- Building can be tedious
 - Many GCC flags
 - Many independent commands
 - Many build targets
 - Many supported architectures
 - Many source files
- Building manually can
 - Cause Consistency issues
 - Waste development time

Linux Kernel Example

- *.c Files: 23,000+
- *.h Files: 18,000+
- *.S Files: 1,400+


Building Manually [S1b]

- Building can be tedious
 - Many GCC flags
 - Many independent commands
 - Many build targets
 - Many supported architectures
 - Many source files



Manually compiling each file and linking is NOT scalable for large software projects or large teams

- Building manually can
 - Cause Consistency issues
 - Waste development time



Large chance for human error

Example Compile in KDS [S2a]

- Project for a KL25z Platform with a Cortex-M0+with containing 2 Source files and some startup Files

12:27:47 **** Build of configuration Debug for project project2 ****

make all

Building file: ../Sources/main.c

Invoking: Cross ARM C Compiler

arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -DTIMER_INTERRUPT=0 -I"../Sources" -I"../Includes" -std=c99 -MMD -MP -MF"Sources/main.d" -MT"Sources/main.o" -c -o

"Sources/main.o" " ../Sources/main.c"

Finished building: ../Sources/main.c

Building file: ../Sources/memory.c

Invoking: Cross ARM C Compiler

arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -DTIMER_INTERRUPT=0 -I"../Sources" -I"../Includes" -std=c99 -MMD -MP -MF"Sources/memory.d" -MT"Sources/memory.o" -c -o

"Sources/memory.o" " ../Sources/memory.c"

Finished building: ../Sources/memory.c

Building file: ../Project_Settings/Startup_Code/startup_MKL25Z4.S

Invoking: Cross ARM GNU Assembler

arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -x assembler-with-cpp -MMD -MP -MF"Project_Settings/Startup_Code/startup_MKL25Z4.d" -

MT"Project_Settings/Startup_Code/startup_MKL25Z4.o" -c -o "Project_Settings/Startup_Code/startup_MKL25Z4.o" " ../Project_Settings/Startup_Code/startup_MKL25Z4.S"

Finished building: ../Project_Settings/Startup_Code/startup_MKL25Z4.S

Building file: ../Project_Settings/Startup_Code/system_MKL25Z4.c

Invoking: Cross ARM C Compiler

arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -DTIMER_INTERRUPT=0 -I"../Sources" -I"../Includes" -std=c99 -MMD -MP -MF"Project_Settings/Startup_Code/system_MKL25Z4.d" -

MT"Project_Settings/Startup_Code/system_MKL25Z4.o" -c -o "Project_Settings/Startup_Code/system_MKL25Z4.o" " ../Project_Settings/Startup_Code/system_MKL25Z4.c"

Finished building: ../Project_Settings/Startup_Code/system_MKL25Z4.c

Building target: project2.elf

Invoking: Cross ARM C++ Linker

arm-none-eabi-g++ -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -T "MKL25Z128xxx4_flash.ld" -Xlinker --gc-sections -

L"C:/classes/boulder/ECEN5013/Spring2016/kds_wksp/project2/Project_Settings/Linker_Files" -Wl,-Map,"project2.map" -specs=nano.specs -specs=nosys.specs -o "project2.elf" ../Sources/main.o ../Sources/memory.o

../Project_Settings/Startup_Code/startup_MKL25Z4.o ../Project_Settings/Startup_Code/system_MKL25Z4.o

Finished building target: project2.elf

12:27:49 Build Finished (took 1s.659ms)

Example Compile in KDS [S2b]

- Project for a KL25z Platform with a Cortex-M0+with containing 2 Source files and some startup Files

```
12:27:47 **** Build of configuration Debug for project project2 ****
```

```
make all
```

```
Building file: ../Sources/main.c
```

```
Invoking: Cross ARM C Compiler
```

```
arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -DTIMER_INTERRUPT=0 -I"../Sources" -I"../Includes" -std=c99 -MMD -MP -MF"Sources/main.d" -MT"Sources/main.o" -c -o "Sources/main.o" "../Sources/main.c"
```

```
Finished building: ../Sources/main.c
```

```
Building file: ../Sources/memory.c
```

```
Invoking: Cross ARM C Compiler
```

```
arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -DTIMER_INTERRUPT=0 -I"../Sources" -I"../Includes" -std=c99 -MMD -MP -MF"Sources/memory.d" -MT"Sources/memory.o" -c -o "Sources/memory.o" "../Sources/memory.c"
```

```
Finished building: ../Sources/memory.c
```

```
Building file: ../Project_Settings/Startup_Code/startup_MKL25Z4.S
```

```
Invoking: Cross ARM GNU Assembler
```

```
arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -x assembler-with-cpp -MMD -MP -MF"Project_Settings/Startup_Code/startup_MKL25Z4.d" -MT"Project_Settings/Startup_Code/startup_MKL25Z4.o" -c -o "Project_Settings/Startup_Code/startup_MKL25Z4.o" "../Project_Settings/Startup_Code/startup_MKL25Z4.S"
```

```
Finished building: ../Project_Settings/Startup_Code/startup_MKL25Z4.S
```

```
Building file: ../Project_Settings/Startup_Code/system_MKL25Z4.c
```

```
Invoking: Cross ARM C Compiler
```

```
arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -DTIMER_INTERRUPT=0 -I"../Sources" -I"../Includes" -std=c99 -MMD -MP -MF"Project_Settings/Startup_Code/system_MKL25Z4.d" -MT"Project_Settings/Startup_Code/system_MKL25Z4.o" -c -o "Project_Settings/Startup_Code/system_MKL25Z4.o" "../Project_Settings/Startup_Code/system_MKL25Z4.c"
```

```
Finished building: ../Project_Settings/Startup_Code/system_MKL25Z4.c
```

```
Building target: project2.elf
```

```
Invoking: Cross ARM C++ Linker
```

```
arm-none-eabi-g++ -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -T "MKL25Z128xxx4_flash.ld" -Xlinker --gc-sections -L"C:/classes/boulder/ECEN5013/Spring2016/kds_wksp/project2/Project_Settings/Linker_Files" -Wl,-Map,"project2.map" -specs=nano.specs -specs=nosys.specs -o "project2.elf" ./Sources/main.o ./Sources/memory.o ./Project_Settings/Startup_Code/startup_MKL25Z4.o ./Project_Settings/Startup_Code/system_MKL25Z4.o
```

```
Finished building target: project2.elf
```

```
12:27:49 Build Finished (took 1s.659ms)
```

Example Compile in KDS [S3]

- Each compile, assemble and link command are
 - More then 100 Characters
 - More then 10 Flags



**Need something to
simplify this!**

Building file: ../Sources/main.c

Invoking: Cross ARM C Compiler

```
arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -I"../Sources" -I"../Includes" -std=c99 -MMD -MP -MF"Sources/main.d" -MT"Sources/main.o" -c -o "Sources/main.o" "../Sources/main.c"
```

Building file: ../Project_Settings/Startup_Code/startup_MKL25Z4.S

Invoking: Cross ARM GNU Assembler

```
arm-none-eabi-gcc -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -x assembler-with-cpp -MMD -MP -MF"Project_Settings/Startup_Code/startup_MKL25Z4.d" -MT"Project_Settings/Startup_Code/startup_MKL25Z4.o" -c -o "Project_Settings/Startup_Code/startup_MKL25Z4.o" "../Project_Settings/Startup_Code/startup_MKL25Z4.S"
```

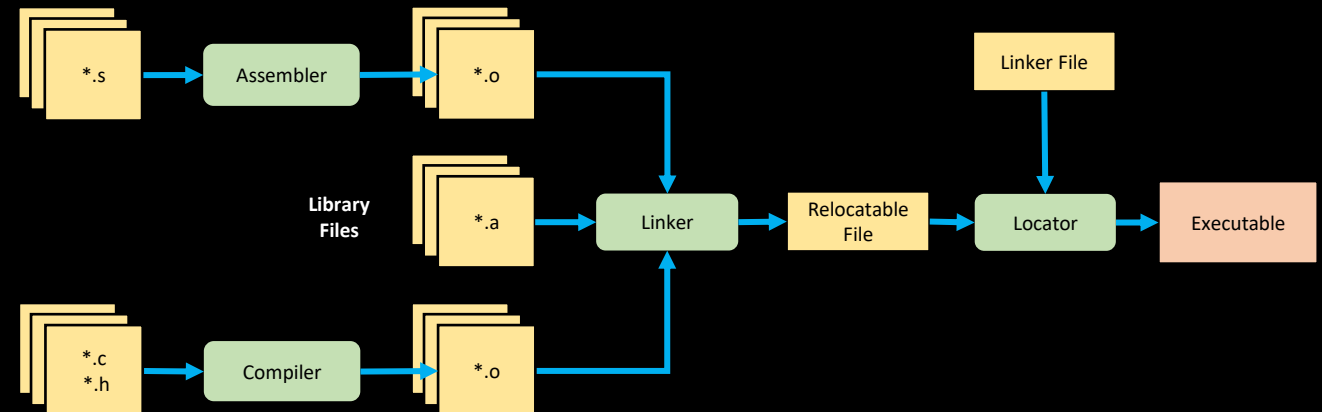
Building target: project.elf

Invoking: Cross ARM C++ Linker

```
arm-none-eabi-g++ -mcpu=cortex-m0plus -mthumb -O0 -fmessage-length=0 -fsigned-char -ffunction-sections -fdata-sections -g3 -T "MKL25Z128xxx4_flash.ld" -Xlinker --gc-sections -L"C:/coursera/kds_wksp/project2/Project_Settings/Linker_Files" -Wl,-Map,"project.map" -specs=nano.specs -specs=nosys.specs -o "project.elf" ./Sources/main.o ./Sources/memory.o ./Sources/ports.o ./Sources/timer.o ./Project_Settings/Startup_Code/startup_MKL25Z4.o ./Project_Settings/Startup_Code/system_MKL25Z4.o
```

Build Management Software [S4]

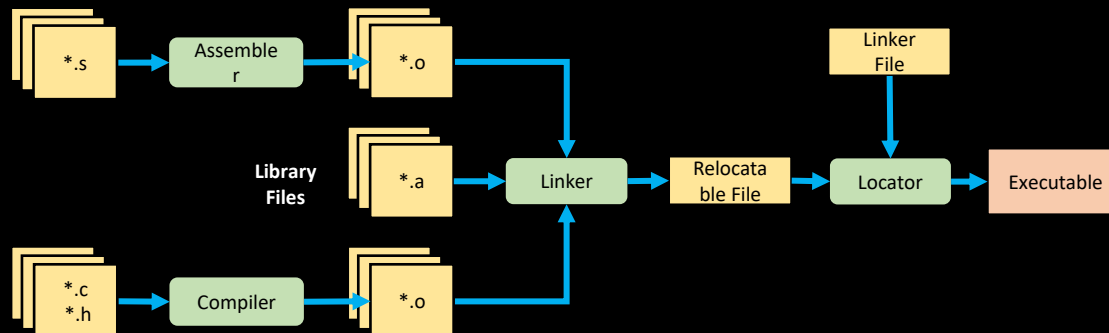
- Build Management Software (or Build Automation) provides a simple and consistent method for producing a target executable
- Automated the process of
 - Preprocessing
 - Assembling
 - Compiling
 - Linking
 - Relocating



GNU Compiler Collection [S5]

- GNU Toolset performs all operations using **make**
 - Preprocessing
 - Assembling
 - Compiling
 - Linking
 - Relocating

```
alex@ubuntu14: ~  
alex@ubuntu14:~$ which make  
/usr/bin/make  
alex@ubuntu14:~$ make -v  
GNU Make 3.81  
Copyright (C) 2006 Free Software Foundation, Inc.  
This is free software; see the source for copying conditions.  
There is NO warranty; not even for MERCHANTABILITY or FITNESS FOR A  
PARTICULAR PURPOSE.  
  
This program built for i686-pc-linux-gnu  
alex@ubuntu14:~$
```



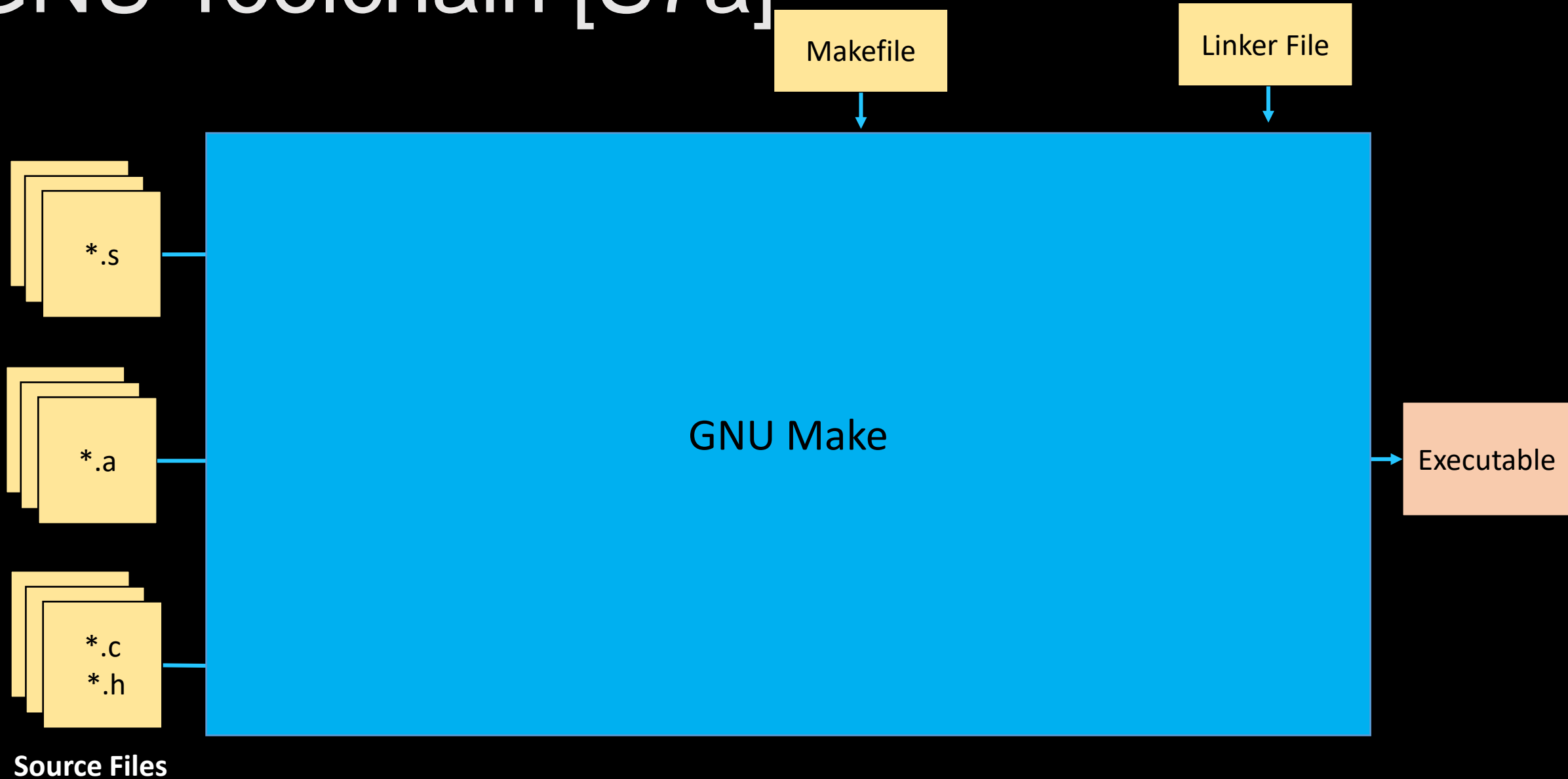
Name	Symbol	ARM Executable
Assembler	as	arm-none-eabi-as
Compiler	gcc	arm-none-eabi-gcc
Linker	ld	arm-none-eabi-ld
Make	make	make

GNU Make [S6]

- GNU Make
 - “Tool that controls the generation of executables and other non-source files of a program from the program’s source files.”²
- GNU = GNU’s Not Unix
 - A collection of software, a **Toolset**
 - Contains GCC = GNUs Compiler Collection
- Make is our Build Management Software
 - Determines what files need to be compiled/recompiled in a project given a **makefile**
 - Helps generate build dependencies and other files
 - Widely used and free



GNU Toolchain [S7a]



Makefiles [S8]

- One or more files used to tell **make** how to build a particular project
 - Invoked from the command line
- Makefiles have build **targets** or build **rules**
 - These are **recipes** for how to build a particular executable or non-source file
- Executables can have **dependencies**
 - Requirements needed for a particular recipe
 - These can be auto-generated from make
- Can define variables/constants to use during compilation
 - Compiler Instance
 - Compiler/Linker Options
 - Architecture to build for

} Compile
Time
Switch



Makefile Rules/Targets [S9]

- Many multiple rules can be executed for any given instance of make that is run
 - Specify target you wish to execute when invoking make

```
$ make main.o
```

```
$ make all
```

```
$ make clean
```



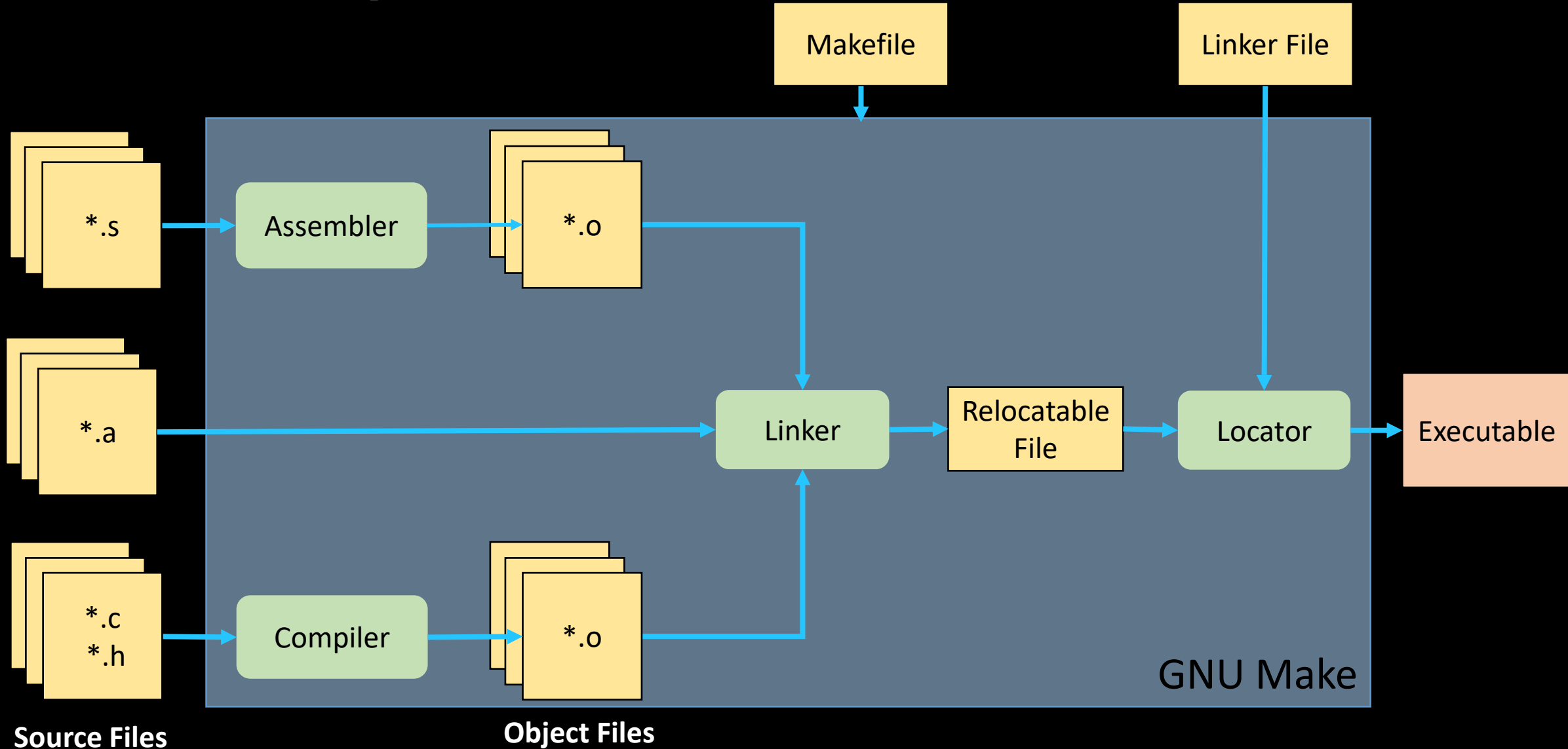
Example Makefile Targets

- If no target is specified, defaults to first defined target in the makefile

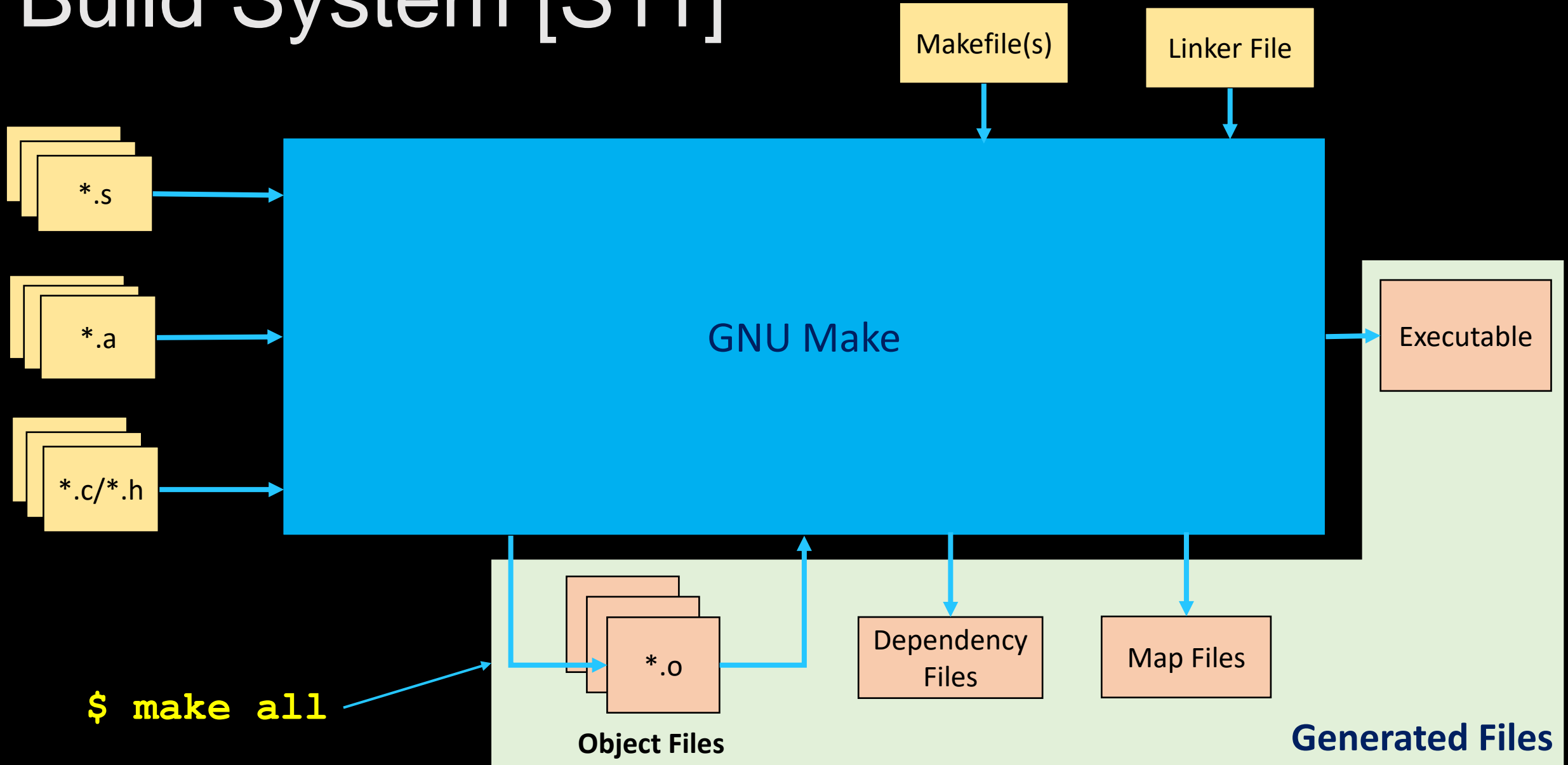
```
$ make
```



GNU Compiler Collection [S10]



Build System [S11]



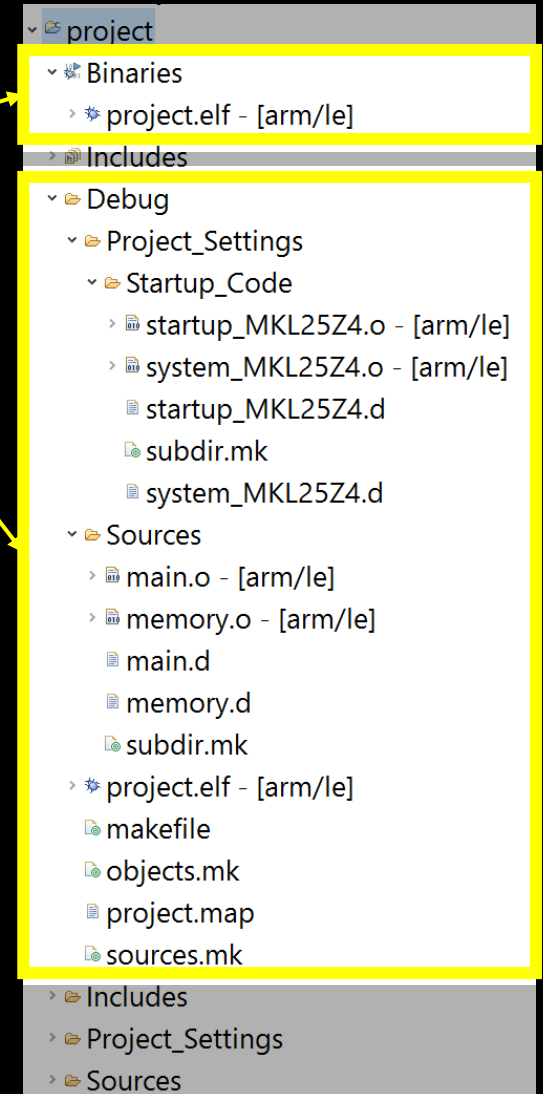
IDE and Make Autogeneration

- Your IDE typically will list Makefiles, output files, and executables in the project explorer
- IDE will dynamically create Makefiles through the use of file auto-generation
 - Software teams DO NOT use IDE autogenerated build systems, they create their own

Banner that gets inserted at the top of all of your auto-generated files

```
#####  
# Automatically-generated file. Do not edit!  
#####
```

Kinetis Design Studio Make Build System



IDE and Make Autogeneration

- Your IDE typically will list Makefiles, output files, and executables in the project explorer
- IDE will dynamically create Makefiles through the use of file auto-generation
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Banner that gets inserted at the top of all of your auto-generated files

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Kinetis Design Studio Make Build System

