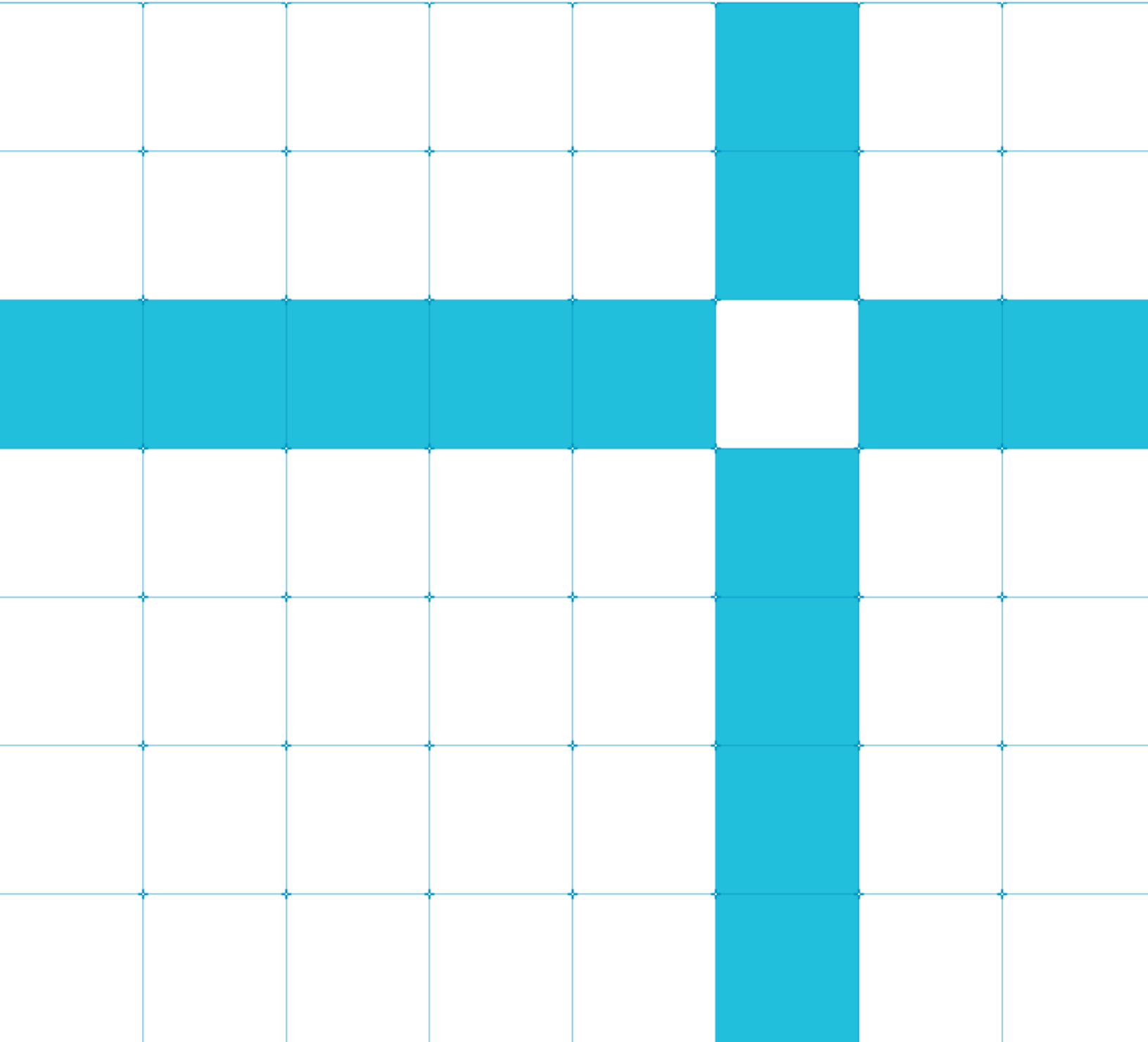




# Cross-compiling Arm NN for the Raspberry Pi and TensorFlow

Version 1.1



## Cross-compiling Arm NN for the Raspberry Pi and TensorFlow

Copyright © 2018 Arm Limited (or its affiliates). All rights reserved.

### Release Information

#### Document History

Version	Date	Confidentiality	Change
1.0	25 October 2018	Non-Confidential	First release
1.1	10 June 2019	Non-Confidential	Minor fixes to the Building Arm NN section

### Non-Confidential Proprietary Notice

This document is protected by copyright and other related rights and the practice or implementation of the information contained in this document may be protected by one or more patents or pending patent applications. No part of this document may be reproduced in any form by any means without the express prior written permission of Arm. **No license, express or implied, by estoppel or otherwise to any intellectual property rights is granted by this document unless specifically stated.**

Your access to the information in this document is conditional upon your acceptance that you will not use or permit others to use the information for the purposes of determining whether implementations infringe any third party patents.

THIS DOCUMENT IS PROVIDED "AS IS". ARM PROVIDES NO REPRESENTATIONS AND NO WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, SATISFACTORY QUALITY, NON-INFRINGEMENT OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE DOCUMENT. For the avoidance of doubt, Arm makes no representation with respect to, and has undertaken no analysis to identify or understand the scope and content of, patents, copyrights, trade secrets, or other rights.

This document may include technical inaccuracies or typographical errors.

TO THE EXTENT NOT PROHIBITED BY LAW, IN NO EVENT WILL ARM BE LIABLE FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES, HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY, ARISING OUT OF ANY USE OF THIS DOCUMENT, EVEN IF ARM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

This document consists solely of commercial items. You shall be responsible for ensuring that any use, duplication or disclosure of this document complies fully with any relevant export laws and regulations to assure that this document or any portion thereof is not exported, directly or indirectly, in violation of such export laws. Use of the word "partner" in reference to Arm's customers is not intended to create or refer to any partnership relationship with any other company. Arm may make changes to this document at any time and without notice.

If any of the provisions contained in these terms conflict with any of the provisions of any click through or signed written agreement covering this document with Arm, then the click through or signed written agreement prevails over and supersedes the conflicting provisions of these terms. This document may be translated into other languages for convenience, and you agree that if there is any conflict between the English version of this document and any translation, the terms of the English version of the Agreement shall prevail.

# Cross-compiling Arm NN for the Raspberry Pi and TensorFlow

ARM062-948681440-2662  
Version 1.1

The Arm corporate logo and words marked with ® or ™ are registered trademarks or trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere. All rights reserved. Other brands and names mentioned in this document may be the trademarks of their respective owners. Please follow Arm's trademark usage guidelines at <http://www.arm.com/company/policies/trademarks>.

Copyright © 2018 Arm Limited (or its affiliates). All rights reserved.

Arm Limited. Company 02557590 registered in England.

110 Fulbourn Road, Cambridge, England CB1 9NJ.

LES-PRE-20349

## Confidentiality Status

This document is Non-Confidential. The right to use, copy and disclose this document may be subject to license restrictions in accordance with the terms of the agreement entered into by Arm and the party that Arm delivered this document to.

Unrestricted Access is an Arm internal classification.

## Product Status

The information in this document is Final, that is for a developed product.

## Web Address

[www.arm.com](http://www.arm.com)

## Contents

<b>1 Overview</b> .....	<b>5</b>
<b>2 Before you begin</b> .....	<b>6</b>
<b>3 Downloading the repositories and bundles</b> .....	<b>7</b>
<b>4 Building the Compute Library</b> .....	<b>8</b>
<b>5 Building the Boost library for your Raspberry Pi</b> .....	<b>9</b>
<b>6 Building the Google Protobuf library</b> .....	<b>10</b>
6.1. Building the Google Protobuf library for your virtual machine .....	10
6.2. Building the Google Protobuf library for your Raspberry Pi.....	10
6.3. Generating the TensorFlow Protobuf library .....	10
<b>7 Building Arm NN</b> .....	<b>11</b>
<b>8 Extracting Arm NN to your Raspberry Pi and running a sample program</b> .....	<b>12</b>
8.1. Creating an archive of cross-compiled libraries, binaries, and directories .....	12
8.2. Extract the libraries, binaries, and directories to your Raspberry Pi .....	12
8.3. Compiling and running a sample Arm NN program on your Raspberry Pi.....	12
<b>9 Testing your build</b> .....	<b>14</b>
<b>10 Next steps</b> .....	<b>15</b>

## 1 Overview

This guide covers what we must do to cross-compile Arm NN using an x86\_64 system to target a Raspberry Pi. Cross-compiling Arm NN allows us to work around the limited memory of the Raspberry Pi. Read the guide to find out how to build the [Compute Library](#), [Boost](#), [Protobuf](#), [TensorFlow](#), and [Arm NN](#) core libraries that you need for compilation. When we finish, we will be able to compile and run programs that use Arm NN on our Raspberry Pis.

Arm estimates that you will take 90-120 minutes to complete this guide.

## 2 Before you begin

This guide assumes:

- You have a Raspberry Pi board. Arm has tested these instructions on a Raspberry Pi 2 Model B V1.1 that runs Raspian 9.
- You compile on a Linux virtual machine. Arm has tested these instructions on an Ubuntu 16.04 virtual machine that runs on MacOS and Windows 10.

You must install the following software tools on your virtual machine:

**Git** A version control system software developers use for source code management.

**Scons** An open-source software construction tool.

**GNU C and C++ compilers for the armhf architecture** The Raspberry Pi uses the armhf Arm architecture.

**Curl** A tool for transferring data to or from a Linux or Unix-like server.

**GNU Autoconf** A tool for producing configure scripts for building, installing and packaging software.

**GNU libtool** A generic library support script.

**CMake** An open-source and cross-platform family of tools for building, testing, and packaging software.

To install the tools you require, open a command window and enter the following commands:

```
sudo apt-get install git
sudo apt-get install scons
sudo apt-get install gcc-arm-linux-gnueabi
sudo apt-get install g++-arm-linux-gnueabi
sudo apt-get install curl
sudo apt-get install autoconf
sudo apt-get install libtool
sudo apt-get install cmake
```

## 3 Downloading the repositories and bundles

Create a directory on your virtual machine to build your Arm NN distribution for your Raspberry Pi.

To create a directory and build your distribution:

1. Enter the following commands:

```
mkdir armnn-pi && cd armnn-pi
export BASEDIR=`pwd`
```

2. Download the Compute Library, Boost, Protobuf, TensorFlow, and Arm NN git repositories and source bundles. To download the repositories and bundles, enter the following commands:

```
git clone https://github.com/Arm-software/ComputeLibrary.git
git clone https://github.com/Arm-software/armnn
wget https://dl.bintray.com/boostorg/release/1.64.0/source/boost_1_64_0.tar.bz2
tar xf boost_1_64_0.tar.bz2
git clone -b v3.5.0 https://github.com/google/protobuf.git
git clone https://github.com/tensorflow/tensorflow.git
```

## 4 Building the Compute Library

Build the Compute Library on your virtual machine. To build the library, enter the following command:

```
cd $BASEDIR/ComputeLibrary
scons extra_cxx_flags="-fPIC" Werror=0 debug=0 asserts=0 neon=1 opencl=0 os=linux arch=armv7a
examples=1
```

Arm estimates that your virtual machine will take approximately 15-20 minutes to execute this command.



# 5 Building the Boost library for your Raspberry Pi

To build the Boost library for your Raspberry Pi:

1. Enter the following commands:

```
cd $BASEDIR/boost_1_64_0/tools/build
./bootstrap.sh
./b2 install --prefix=$BASEDIR/boost.build
export PATH=$BASEDIR/boost.build/bin:$PATH
```

2. Create a `project-config.jam` file by copying the `user-config.jam` file. To copy the `user-config.jam` file, enter the following command:

```
cp $BASEDIR/boost_1_64_0/tools/build/example/user-config.jam
$BASEDIR/boost_1_64_0/project-config.jam
```

Go to the `$BASEDIR/boost_1_64_0/` directory and open the `project-config.jam` file in a text editor. In the GCC Configuration section, add the following line:

```
using gcc : arm : arm-linux-gnueabi-g++ ;
```

Save the `project-config.jam` file in the `$BASEDIR/boost_1_64_0/` directory.

3. To complete the build, enter the following commands:

```
cd $BASEDIR/boost_1_64_0
b2 --build-dir=$BASEDIR/boost_1_64_0/build toolset=gcc-arm link=static cxxflags=-fPIC --with-filesystem --with-test --with-log --with-program_options install --prefix=$BASEDIR/boost
```

Arm estimates that your virtual machine will take approximately 15 minutes to execute these commands.

## 6 Building the Google Protobuf library

You use two versions of the Google Protobuf library. One version of the library runs on your virtual machine and the other runs on your Raspberry Pi.

### 6.1. Building the Google Protobuf library for your virtual machine

To build the Google Protobuf library for your virtual machine:

1. Enter the following commands:

```
cd $BASEDIR/protobuf
git submodule update --init --recursive
./autogen.sh
./configure --prefix=$BASEDIR/protobuf-host
make
```

Arm estimates that your virtual machine will take approximately 15 minutes to execute these commands.

2. Enter the following commands:

```
make install
make clean
```

### 6.2. Building the Google Protobuf library for your Raspberry Pi

To build the Google Protobuf library for your Raspberry Pi:

1. Enter the following commands:

```
./configure --prefix=$BASEDIR/protobuf-arm --host=arm-linux CC=arm-linux-gnueabi-gcc
CXX=arm-linux-gnueabi-g++ --with-protoc=$BASEDIR/protobuf-host/bin/protoc
make
```

Arm estimates that your virtual machine will take approximately 15 minutes to execute these commands.

2. Enter the following command:

```
make install
```

### 6.3. Generating the TensorFlow Protobuf library

To generate the TensorFlow library, enter the following commands:

```
cd $BASEDIR/tensorflow
../armnn/scripts/generate_tensorflow_protobuf.sh ../tensorflow-protobuf ../protobuf-host
```

## 7 Building Arm NN

To build Arm NN:

1. Enter the following commands:

```
cd $BASEDIR/armnn
mkdir build
cd build
```

2. Place the library files you require in the build directory. To place the library files, enter:

```
cmake .. -DCMAKE_LINKER=/usr/bin/arm-linux-gnueabi-hf-ld \
-DCMAKE_C_COMPILER=/usr/bin/arm-linux-gnueabi-hf-gcc \
-DCMAKE_CXX_COMPILER=/usr/bin/arm-linux-gnueabi-hf-g++ \
-DCMAKE_C_COMPILER_FLAGS=-fPIC \
-DCMAKE_CXX_FLAGS=-mfpu=neon \
-DARMCOMPUTE_ROOT=$BASEDIR/ComputeLibrary \
-DARMCOMPUTE_BUILD_DIR=$BASEDIR/ComputeLibrary/build \
-DBOOST_ROOT=$BASEDIR/boost \
-DTF_GENERATED_SOURCES=$BASEDIR/tensorflow-protobuf \
-DBUILD_TF_PARSER=1 \
-DPROTOBUF_ROOT=$BASEDIR/protobuf-arm \
-DARMCOMPUTENEON=1
make
```

Arm estimates that your virtual machine will take approximately 12 minutes to execute these commands.

## 8 Extracting Arm NN to your Raspberry Pi and running a sample program

### 8.1. Creating an archive of cross-compiled libraries, binaries, and directories

To create an archive of cross-compiled libraries, binaries, and directories:

1. Copy the following libraries, binaries, and directories from your virtual machine. To copy these libraries, binaries, and directories enter the following commands:

```
cd $BASEDIR
mkdir armnn-dist
mkdir armnn-dist/armnn
mkdir armnn-dist/armnn/lib

cp $BASEDIR/armnn/build/libarmnn.so $BASEDIR/armnn-dist/armnn/lib
cp $BASEDIR/armnn/build/libarmnnTfParser.so $BASEDIR/armnn-dist/armnn/lib
cp $BASEDIR/protobuf-arm/lib/libprotobuf.so.15.0.0 $BASEDIR/armnn-dist/armnn/lib/libprotobuf.so
cp $BASEDIR/protobuf-arm/lib/libprotobuf.so.15.0.0 $BASEDIR/armnn-dist/armnn/lib/libprotobuf.so.15
cp -r $BASEDIR/armnn/include $BASEDIR/armnn-dist/armnn/include
cp -r $BASEDIR/boost $BASEDIR/armnn-dist/boost
```

2. Copy the Unit Tests and a sample Arm NN program. To copy this test and program, enter the following commands:

```
cp $BASEDIR/armnn/build/UnitTests $BASEDIR/armnn-dist
cp $BASEDIR/armnn/samples/SimpleSample.cpp $BASEDIR/armnn-dist
```

3. Create the archive for your Raspberry Pi. To create the archive, enter the following command:

```
tar -czf $BASEDIR/armnn-dist.tar.gz armnn-dist
```

### 8.2. Extract the libraries, binaries, and directories to your Raspberry Pi

Extract the libraries, binaries, and directories to your Raspberry Pi. To extract the libraries, binaries, and directories enter the following commands:

```
cd /home/pi
tar -xzf /home/pi/armnn-dist.tar.gz
```

### 8.3. Compiling and running a sample Arm NN program on your Raspberry Pi

To compile and run a sample C++ program that uses Arm NN on your Raspberry Pi:

1. Enter the following commands:

# Cross-compiling Arm NN for the Raspberry Pi and TensorFlow

```
export LD_LIBRARY_PATH=/home/pi/armnn-dist/armnn/lib  
cd /home/pi/armnn-dist
```

To compile the program, enter the following commands:

```
g++ SimpleSample.cpp -I/home/pi/armnn-dist/armnn/include -I/home/pi/armnn-dist/boost/include -  
L/home/pi/armnn-dist/armnn/lib -larmnn -larmnnTfParser -lprotobuf -o SimpleSample
```

2. To run the program, enter the following commands:

```
./SimpleSample
```

The console returns the following:

```
Please enter a number:
```

Enter your number. For example:

```
345
```

The console returns the following:

```
Your number was 345
```

## 9 Testing your build

To test that your build of Arm NN works correctly, run the Unit Tests. To run the Unit Tests, enter the following:

```
export LD_LIBRARY_PATH=/home/pi/armnn-dist/armnn/lib
cd /home/pi/armnn-dist
./UnitTests
```

If the tests are successful, they output the following to the console:

```
*** No errors detected
```

If some of the tests are unsuccessful, go back through the steps and check that all the commands have been entered correctly.

## 10 Next steps

You are now ready to compile and run programs that use Arm NN on your Raspberry Pi.

Find out how to deploy [Caffe](#) and [TensorFlow](#) models.