kdiv user manual

Title	kdiv (Constant division routine generator)
Author	Nikolaos Kavvadias
Contact	nikolaos.kavvadias@gmail.com
Website	http://www.nkavvadias.com
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Rev. history	
v0.1.3	2017-09-14 Generalize `magic` and `magicu` for any bitwidth up to 32 bits.
v0.1.2	2016-04-12 Cumulative update; better flag management, cleanup script.
v0.1.1	2014-11-29 Added project logo in README.
v0.1.0	2014-10-16 Documentation updates and fixes.
v0.0.9	2014-06-13 Renamed README to README.rst.
v0.0.8	2014-06-12 Updated contact information. Replaced COPYING.BSD by LICENSE.
v0.0.7	2013-04-28 Converted documentation to RestructuredText.
v0.0.6	2012-03-17 Split build-and-test scripts to `build` and `test`.
v0.0.5	2011-12-03 Minor README updates regarding multiple releases, tutorial usage.
v0.0.4	2011-11-20 Minor README, Makefile updates.
v0.0.3	2011-11-09 Added omitted constant value for M in C routines.

v0.0.2	2011-09-16 Small fixes, avoids emitting redundant shift.
v0.0.1	2011-05-21 Initial release.

1. Introduction

`kdiv` is a generator for routines for optimized division by an integer constant. It can be used for calculating an integer division with the routines presented in Henry S. Warren's "Hacker's Delight" book. `kdiv` can also be used for emitting a NAC (generic assembly language) or ANSI C implementation of the division.

2. File listing

The `kdiv` distribution includes the following files:

/kdiv	Top-level directory
LICENSE	Description of the Modified BSD license.
Makefile	Makefile for generating the `kdiv` executable.
README.html	HTML version of README.rst.
README.pdf	PDF version of README.rst.
README.rst	This file.
build.sh	Build script for `kdiv`.
clean.sh	Clean-up the produced files from `test.sh`.
kdiv.c	The source code for the application.
kdiv.png	PNG image for the `kdiv` project logo.
rst2docs.sh	Bash script for generating the HTML and PDF versions.
test.c	Sample test file.
test.opt.c	Expected optimized version of `test.c`.
test.sh	Perform some sample runs.

3. Installation

There exists a quite portable Makefile (`Makefile` in the current directory). Running `make` from the command prompt should compile `kdiv`.

4. Prerequisites

- [mandatory for building] Standard UNIX-based tools
- gcc (tested with gcc-3.4.4 on cygwin/x86)
- make

- bash

5. kdiv usage

The `kdiv` program can be invoked with several options (see complete option listing below). The usual tasks that can be accomplished with `kdiv` are:

- test signed/unsigned division by constant
- generate a NAC optimized software routine for the division
- generate an ANSI C optimized software routine for the division.

ANSI C routines have been tested only for a width of 32-bits (see option below). `kdiv` can be invoked as:

```
$./kdiv [options]
```

The complete `kdiv` options listing:

-h Print this help.

-d Enable debug/diagnostic output.

-errors Report only inconsistencies to the expected division results.

-div <num> Set the value of the divisor (an integer except zero). Default: 1.

-width <num> Set the bitwidth of all operands: dividend, divisor and quotient. Default: 32.

-lo <num> Set the lower integer bound for dividend testing. Debug output (`-d`) must be enabled. Default: 0.

-hi <num> Set the higher integer bound for dividend testing. Debug output (`-d`) must be enabled. Default: 65535.

-signed Construct optimized routine for signed division.

-unsigned Construct optimized routine for unsigned division (default).

-nac Emit software routine in the NAC general assembly language (default).

-ansic Emit software routine in ANSI C (only for `width=32`).

Here follow some simple usage examples of `kdiv`.

1. Generate the ANSI C implementation of the optimized routine for `n / 11`.

```
$ ./kdiv -div 11 -width 32 -unsigned -ansic
```

2. Generate the NAC implementation of the optimized routine for `n / (-7)`.

```
$ ./kdiv -div -7 -width 32 -signed -ansic
```

3. Generate the ANSI C implementation of the optimized routine `n / 23`. Also run some tests with an internal generator for the dividend range [0..1024].

```
$ ./kdiv -div 23 -width 32 -unsigned -ansic -d -lo 0 -hi
1024
```

6. Quick tutorial

`kdiv` can be used for arithmetic optimizations in user programs. Assume the following user program (`test.c`):

```
// test.c
#include <stdio.h>
#include <stdlib.h>
int main(int argc, char *argv[]) {
  int a, b;
  a = atoi(argv[1]);
  b = a / 23;
  printf("b = %d\n", b);
  return b;
}
```

This file is compiled and run as follows with one additional argument:

```
$ gcc -Wall -O2 -o test.exe test.c
$ ./test.exe 155
```

and the expected result is:

```
$ b = 6
```

The user can apply `kdiv` for generating a constant division routine for `a/23`:

```
$ ./kdiv -div 23 -width 32 -signed -ansic
```

and the corresponding routine is produced. Then, the user should edit a new file, let's say `test.opt.c` and include the produced routine. The resulting optimized source file should be as follows:

```
// test.opt.c
#include <stdio.h>
#include <stdlib.h>
inline signed int kdiv_s32_p_23 (signed int n)
{
  signed int q, M=-1307163959, c;
  signed long long int t, u, v;
  t = (signed long long int)M * (signed long long int)n;
  q = t >> 32;
  q = q + n;
  q = q >> 4;
```

```
  c = n >> 31;
  q = q + c;
  return (q);
}

int main(int argc, char *argv[]) {
  int a, b;
  a = atoi(argv[1]);
  b = kdiv_s32_p_23(a);
  printf("b = %d\n", b);
  return b;
}
```

This file is compiled and run as follows with one additional argument:

```
$ gcc -Wall -O2 -o test.opt.exe test.opt.c
$ ./test.opt.exe 155
```

The target platform compiler (e.g. `gcc` or `llvm`) is expected to inline the `kdiv_s32_p_23` function at its call site.

7. Running tests

In order to build and run a series of sample tests do the following:

```
$ ./build.sh
$ ./test.sh
```

To clean-up the produced files from `test.sh` and only these use:

```
$ ./clean.sh
```