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--
-- Purpose:
--
--   Carry Chain Adder
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-- Discussion:
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-- Licensing:
--
--   This code is distributed under the GNU LGPL license.
--
-- Modified:
--
--   2012.08.24
--
-- Author:
--
--   Young W. Lim
--
-- Parameters:
--
--   Input:
--
--   Output:
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```

```
library STD;
use STD.textio.all;
```

```
library IEEE;
use IEEE.std_logic_1164.all;
use IEEE.numeric_std.all;
```

```
entity adder is
  generic (
    WD    : in natural := 32;
    BD    : in natural := 4 );

  port (
    an    : in   std_logic_vector (WD-1 downto 0) := (others=>'0');
    bn    : in   std_logic_vector (WD-1 downto 0) := (others=>'0');
    ci    : in   std_logic := '0';
    cn    : out  std_logic_vector (WD-1 downto 0) := (others=>'0');
    co    : out  std_logic := '0');
```

```
end adder;
```

```
-----
-- an : 1st operand (WD-bit)
-- bn : 2nd operand (WD-bit)
-- ci : carry in (1-bit)
-- cn : result (WD-bit)
-- co : carry out (1-bit)
-----
```

```
architecture cca of adder is
```

```
  component Badder is
    generic (
      WD    : in natural := 4);

    port (
      an    : in   std_logic_vector (WD-1 downto 0);
      bn    : in   std_logic_vector (WD-1 downto 0);
      ci    : in   std_logic := '0';
      cn    : out  std_logic_vector (WD-1 downto 0);
```

```

    co    : out  std_logic := '0');
end component;

constant ND : natural := WD/BD;

-- an2d, bn2d, cn2d : array(ND, BD) <= an, bn, cn
-- cild, cold      : array(ND)      <= ci, co
-- gld, pld       : array(ND)      -- Generate, Propagate
-- qild, qold     : array(ND)      -- CarryChainIn, CarryChainOut

type array2d is array (ND-1 downto 0) of std_logic_vector (BD-1 downto 0);
signal an2d, bn2d, cn2d: array2d := ((others=> (others=> '0')));

type array1d is array (ND-1 downto 0) of std_logic;
signal cild, cold : array1d := (others=> '0');
signal gld, pld  : array1d := (others=> '0');
signal qild, qold : array1d := (others=> '0');

```

**begin**

```

-- ND Adders of BD-bit
-- cild(i) : carry in of the i-th BD-bit adder
-- cold(i) : carry out of the i-th BD-bit adder
-- cn2d(i, j) : j-th bit of the result of the i-th BD-bit adder
ILOOP: for i in ND-1 downto 0 generate
    U0: Badder generic map (WD => BD)
        port map (an => an2d(i),
                 bn => bn2d(i),
                 ci => cild(i),
                 cn => cn2d(i),
                 co => cold(i) );
end generate ILOOP;

```

```

-- Carry Chain GP Logic
-- gld(i) : carry generation of the i-th BD-bit adder
--         cn2d(i) > BD-1
-- pld(i) : carry propagation of the i-th BD-bit adder
--         cn2d(i) = BD-1

```

```

process (cold)
    variable tmp1d : array1d := (others=> '0');
begin
    tmp1d := cold;

    for i in ND-1 downto 0 loop
        gld(i) <= cold(i);
    end loop;
end process;

```

```

process (cn2d)
    variable tmp2d: array2d := ((others=> (others=> '0')));
    variable tmpv : std_logic_vector (BD-1 downto 0) := (others=>'0');
    variable tmp  : std_logic := '0';
begin
    tmp2d := cn2d;

    for i in ND-1 downto 0 loop
        tmpv := tmp2d(i);
        tmp := '0';
        for j in BD-1 downto 0 loop
            tmp := tmp and tmpv(j);
        end loop;
        pld(i) <= tmp;
    end loop;
end process;

```

```
-- Carry Chain Cell
-- qild(i) : input of a carry chain cell
-- qold(i) : output of a carry chain cell
```

```
process (ci, qold)
  variable tmpld : arrayld := (others=> '0');
  variable tmp : std_logic := '0';
begin
  tmp := ci;
  tmpld := qold;

  for i in ND-1 downto 1 loop
    qild(i) <= qold(i-1);
  end loop;

  qild(0) <= tmp;
end process;
```

```
process (pld, gld, qild)
  variable tmpld_p, tmpld_g, tmpld_qi : arrayld := (others=> '0');
begin

  tmpld_p := pld;
  tmpld_g := gld;
  tmpld_qi := qild;

  for i in ND-1 downto 0 loop
    if (tmpld_p(i) = '1') then
      qold(i) <= tmpld_qi(i);
    else
      qold(i) <= tmpld_g(i);
    end if;
  end loop;
end process;
```

```
end cca;
```