Integral Casting Conversions

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Casts Involving Integral Types (§6.2.3)

- Other than for _Bool, casts from one integral type to another should maintain the mathematical value, if possible
- If the cast **cannot maintain the value of the original expression**, then
  - If converting from unsigned to signed, then the result is not defined
  - If converting from signed to unsigned, then the result must be equal to the original value mod 2^n, where *n* is the number of bits in the representation of the result type
  - Keep in mind that the result of modulo has the same sign as the divisor
  - Reminder: the **%** operator in C does not compute *modulo*; rather, its result is the *remainder*

Integral Casts Where Value is Maintained

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 255; ui = (unsigned int)uc; /* ui will have the value ??? */
  - uc = 255; si = (signed int)uc; /* si will have the value ??? */
  - sc = -1; si = (signed int)sc; /* si will have the value ??? */

Integral Casts Where Value is Maintained

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 255; ui = (unsigned int)uc; /* ui will have the value 255 */
  - uc = 255; si = (signed int)uc; /* si will have the value ??? */
  - sc = -1; si = (signed int)sc; /* si will have the value ??? */

Integral Casts Where Value is Maintained

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 255; ui = (unsigned int)uc; /* ui will have the value 255 */
  - uc = 255; si = (signed int)uc; /* si will have the value 255 */
  - sc = -1; si = (signed int)sc; /* si will have the value ??? */

Integral Casts Where Value is Maintained

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 255; ui = (unsigned int)uc; /* ui will have the value 255 */
  - uc = 255; si = (signed int)uc; /* si will have the value 255 */
  - sc = -1; si = (signed int)sc; /* si will have the value -1 */

Integral Casts to Same Size Destination Types

- Bottom line: If integral types are represented in two's-complement, then no conversion is required when performing conversions between signed and unsigned types ***of the same size***
  - Regarding conversion of an unsigned to a signed integer of the same size that would overflow, H&S states that, "many programmers and programs depend on the conversion being performed quietly and with no change of representation to produce a negative number"

- Therefore, we won't emit any IR for same size casts

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value ??? */
  - uc = 127; sc = (signed char)uc; /* sc will have the value ??? */
  - uc = 128; sc = (signed char)uc; /* sc will have the value ??? */
  - uc = 255; sc = (signed char)uc; /* sc will have the value ??? */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value ??? */
  - uc = 128; sc = (signed char)uc; /* sc will have the value ??? */
  - uc = 255; sc = (signed char)uc; /* sc will have the value ??? */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value 127 */
  - uc = 128; sc = (signed char)uc; /* sc will have the value ??? */
  - uc = 255; sc = (signed char)uc; /* sc will have the value ??? */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value 127 */
  - uc = 128; sc = (signed char)uc; /* sc will have the value -128 (C: undefined) */
  - uc = 255; sc = (signed char)uc; /* sc will have the value ??? */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value 127 */
  - uc = 128; sc = (signed char)uc; /* sc will have the value -128 (C: undefined) */
  - uc = 255; sc = (signed char)uc; /* sc will have the value -1 (C: undefined) */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value 127 */
  - uc = 128; sc = (signed char)uc; /* sc will have the value -128 (C: undefined) */
  - uc = 255; sc = (signed char)uc; /* sc will have the value -1 (C: undefined) */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value 0 */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value 127 */
  - uc = 128; sc = (signed char)uc; /* sc will have the value -128 (C: undefined) */
  - uc = 255; sc = (signed char)uc; /* sc will have the value -1 (C: undefined) */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value 0 */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value 127 */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value ??? */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value 127 */
  - uc = 128; sc = (signed char)uc; /* sc will have the value -128 (C: undefined) */
  - uc = 255; sc = (signed char)uc; /* sc will have the value -1 (C: undefined) */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value 0 */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value 127 */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value 128 */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value ??? */

Examples of Integral Casts to Same Size Destinations

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - uc = 0; sc = (signed char)uc; /* sc will have the value 0 */
  - uc = 127; sc = (signed char)uc; /* sc will have the value 127 */
  - uc = 128; sc = (signed char)uc; /* sc will have the value -128 (C: undefined) */
  - uc = 255; sc = (signed char)uc; /* sc will have the value -1 (C: undefined) */
  - sc = 0; uc = (unsigned char)sc; /* uc will have the value 0 */
  - sc = 127; uc = (unsigned char)sc; /* uc will have the value 127 */
  - sc = -128; uc = (unsigned char)sc; /* uc will have the value 128 */
  - sc = -1; uc = (unsigned char)sc; /* uc will have the value 255 */

Integral Casts to Wider Destination Types

- The only case in which an integer conversion to a wider destination is **not representable** is when the **source is signed and negative** and the **destination is unsigned**
- C requires that a cast to a wider unsigned destination type from a signed type when the value is negative must behave as if the cast were first made to a signed type with the same size as the destination and then converted to be unsigned
  - In all other cases, the result of the conversion will have the same mathematical value as the source

- Example:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - sc = -1; ui = (unsigned int)sc;
  - must behave as if it were
  - sc = -1; ui = (unsigned int)(signed int)sc;

  - sc = -1; ui = (unsigned int)sc; /* ui will have the value 0xffffffff */

Integral Casts to Narrower Destination Types

- When converting from a unsigned source to an unsigned destination, excess high-order bits can be discarded
- When converting from a signed source to an unsigned destination, then excess high-order bits can be discarded
  - The value is representable only if it is non-negative
- When converting from a signed or unsigned source to an signed destination, if integers use two's-complement representation, then excess high-order bits can be discarded
  - In all cases, if the result value is representable, it will still be representable after discarding excess high-order bits

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value ??? */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value ??? */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value ??? */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value ??? */

  - si = 0; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value ??? */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value ??? */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value ??? */

  - si = 0; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value ??? */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value ??? */

  - si = 0; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value ??? */

  - si = 0; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = 255; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = 255; uc = (unsigned char)si; /* uc will have the value 255 */
  - si = 256; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = 255; uc = (unsigned char)si; /* uc will have the value 255 */
  - si = 256; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = -127; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = 255; uc = (unsigned char)si; /* uc will have the value 255 */
  - si = 256; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = -127; uc = (unsigned char)si; /* uc will have the value 129 */
  - si = -128; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = 255; uc = (unsigned char)si; /* uc will have the value 255 */
  - si = 256; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = -127; uc = (unsigned char)si; /* uc will have the value 129 */
  - si = -128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = -129; uc = (unsigned char)si; /* uc will have the value ??? */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = 255; uc = (unsigned char)si; /* uc will have the value 255 */
  - si = 256; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = -127; uc = (unsigned char)si; /* uc will have the value 129 */
  - si = -128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = -129; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = -1; uc = (unsigned char)si; /* uc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (1 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 255; uc = (unsigned char)ui; /* uc will have the value 255 */
  - ui = 256; uc = (unsigned char)ui; /* uc will have the value 0 */
  - ui = 257; uc = (unsigned char)ui; /* uc will have the value 1 */

  - si = 0; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = 127; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = 128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = 255; uc = (unsigned char)si; /* uc will have the value 255 */
  - si = 256; uc = (unsigned char)si; /* uc will have the value 0 */
  - si = -127; uc = (unsigned char)si; /* uc will have the value 129 */
  - si = -128; uc = (unsigned char)si; /* uc will have the value 128 */
  - si = -129; uc = (unsigned char)si; /* uc will have the value 127 */
  - si = -1; uc = (unsigned char)si; /* uc will have the value 255 */

Examples of Integral Casts to Narrower Destinations (2 of 2)

- Examples:
  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; sc = (signed char)ui; /* sc will have the value ??? */
  - ui = 255; sc = (signed char)ui; /* sc will have the value ??? */
  - ui = 256; sc = (signed char)ui; /* sc will have the value ??? */
  - ui = 257; sc = (signed char)ui; /* sc will have the value ??? */
  - ui = 384; sc = (signed char)ui; /* sc will have the value ??? */
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  - si = 256; sc = (signed char)si; /* sc will have the value ??? */
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  - si = -128; sc = (signed char)si; /* sc will have the value ??? */
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Examples of Integral Casts to Narrower Destinations (2 of 2)

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  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

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  - si = 256; sc = (signed char)si; /* sc will have the value ??? */
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Examples of Integral Casts to Narrower Destinations (2 of 2)

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  - si = 128; sc = (signed char)si; /* sc will have the value ??? */
  - si = 255; sc = (signed char)si; /* sc will have the value ??? */
  - si = 256; sc = (signed char)si; /* sc will have the value ??? */
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  - si = 127; sc = (signed char)si; /* sc will have the value 127 */
  - si = 128; sc = (signed char)si; /* sc will have the value -128 */
  - si = 255; sc = (signed char)si; /* sc will have the value ??? */
  - si = 256; sc = (signed char)si; /* sc will have the value ??? */
  - si = -127; sc = (signed char)si; /* sc will have the value ??? */
  - si = -128; sc = (signed char)si; /* sc will have the value ??? */
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Examples of Integral Casts to Narrower Destinations (2 of 2)

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  - si = 0; sc = (signed char)si; /* sc will have the value 0 */
  - si = 127; sc = (signed char)si; /* sc will have the value 127 */
  - si = 128; sc = (signed char)si; /* sc will have the value -128 */
  - si = 255; sc = (signed char)si; /* sc will have the value -1 */
  - si = 256; sc = (signed char)si; /* sc will have the value ??? */
  - si = -127; sc = (signed char)si; /* sc will have the value ??? */
  - si = -128; sc = (signed char)si; /* sc will have the value ??? */
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Examples of Integral Casts to Narrower Destinations (2 of 2)

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  - ui = 0; sc = (signed char)ui; /* sc will have the value 0 */
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  - ui = 256; sc = (signed char)ui; /* sc will have the value 0 */
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  - ui = 384; sc = (signed char)ui; /* sc will have the value -128 */
  - ui = 511; sc = (signed char)ui; /* sc will have the value -1 */

  - si = 0; sc = (signed char)si; /* sc will have the value 0 */
  - si = 127; sc = (signed char)si; /* sc will have the value 127 */
  - si = 128; sc = (signed char)si; /* sc will have the value -128 */
  - si = 255; sc = (signed char)si; /* sc will have the value -1 */
  - si = 256; sc = (signed char)si; /* sc will have the value 0 */
  - si = -127; sc = (signed char)si; /* sc will have the value ??? */
  - si = -128; sc = (signed char)si; /* sc will have the value ??? */
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  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

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  - si = 0; sc = (signed char)si; /* sc will have the value 0 */
  - si = 127; sc = (signed char)si; /* sc will have the value 127 */
  - si = 128; sc = (signed char)si; /* sc will have the value -128 */
  - si = 255; sc = (signed char)si; /* sc will have the value -1 */
  - si = 256; sc = (signed char)si; /* sc will have the value 0 */
  - si = -127; sc = (signed char)si; /* sc will have the value -127 */
  - si = -128; sc = (signed char)si; /* sc will have the value ??? */
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Examples of Integral Casts to Narrower Destinations (2 of 2)

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  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

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  - ui = 255; sc = (signed char)ui; /* sc will have the value -1 */
  - ui = 256; sc = (signed char)ui; /* sc will have the value 0 */
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  - si = 0; sc = (signed char)si; /* sc will have the value 0 */
  - si = 127; sc = (signed char)si; /* sc will have the value 127 */
  - si = 128; sc = (signed char)si; /* sc will have the value -128 */
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  - si = 256; sc = (signed char)si; /* sc will have the value 0 */
  - si = -127; sc = (signed char)si; /* sc will have the value -127 */
  - si = -128; sc = (signed char)si; /* sc will have the value -128 */
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  - si = 256; sc = (signed char)si; /* sc will have the value 0 */
  - si = -127; sc = (signed char)si; /* sc will have the value -127 */
  - si = -128; sc = (signed char)si; /* sc will have the value -128 */
  - si = -129; sc = (signed char)si; /* sc will have the value 127 */
  - si = -1; sc = (signed char)si; /* sc will have the value ??? */

Examples of Integral Casts to Narrower Destinations (2 of 2)

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  - signed char sc; unsigned char uc; signed int si; unsigned int ui;

  - ui = 0; sc = (signed char)ui; /* sc will have the value 0 */
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  - si = 255; sc = (signed char)si; /* sc will have the value -1 */
  - si = 256; sc = (signed char)si; /* sc will have the value 0 */
  - si = -127; sc = (signed char)si; /* sc will have the value -127 */
  - si = -128; sc = (signed char)si; /* sc will have the value -128 */
  - si = -129; sc = (signed char)si; /* sc will have the value 127 */
  - si = -1; sc = (signed char)si; /* sc will have the value -1 */

How Does This Affect the IR (1 of 2)

- Our IR assumes two's-complement representation for integers
- No IR emitted for same size conversions
- Conversion to wider destination types emit a cast based on the **source signedness**
  - castUnsignedHalfWordToWord
  - castSignedHalfWordToWord
  - castUnsignedByteToHalfWord
  - castSignedByteToHalfWord
  - castUnsignedByteToWord
  - castSignedByteToWord

How Does This Affect the IR (2 of 2)

- Conversion to narrower destination types emit a cast independent of signedness
  - castWordToHalfWord
  - castWordToByte
  - castHalfWordToByte

How are Narrowing Casting Conversions Mapped Into MIPS Code

- For narrowing conversions…
  - The only code that needs to be emitted is to copy from the source register to the destination register
  - No zero- or sign-extension is necessary when narrowing in a register, because that will happen when the value in the destination register is later used

- For example,

  (castWordToByte, r1, r0)

- might generate

  or $s1, $s0, $0

Mapping Unsigned Widening Casting Conversions Into MIPS Code

- For unsigned widening conversions…
  - The code that needs to be emitted needs to copy from the source register to the destination register and zero-extend into the high-order bits

- For example,
  (castUnsignedByteToWord, r1, r0)
- might generate
  andi $s1, $s0, 0xff # $s1 <- $s0 least significant byte (all other bits are 0)
- And, for example,
  (castUnsignedHalfWordToWord, r1, r0)
- might generate
  andi $s1, $s0, 0xffff # $s1 <- $s0's two least significant bytes (all other bits are 0)

Mapping Signed Widening Casting Conversions Into MIPS Code

- For signed widening conversions…
  - The code that needs to be emitted needs to copy from the source register to the destination register and sign-extend into the high-order bits

- For example,

  (castSignedByteToWord, r1, r0)

- might generate

```
sll  $s1, $s0, 24        # $s1 <- $s0 << 24 (shifting in 0 bits)
sra  $s1, $s1, 24        # $s1 <- $s1 >> 24 (sign extending)
```

- And, for example,

  (castSignedHalfWordToWord, r1, r0)

- might generate

```
sll  $s1, $s0, 16        # $s1 <- $s0 << 16 (shifting in 0 bits)
sra  $s1, $s1, 16        # $s1 <- $s1 >> 16 (sign extending)
```