

10 Optimising Compilers (tcg40)

- (a) We create an abstract interpretation named “*known-bits*” analysis, which computes for each value two bitvectors (stored as `uint8_t`):

```
struct AbstractValueKB {
    uint8_t one; // A bit is `set` if the corresponding bit of
                // the concrete value is known to be '1'.
    uint8_t zero; // A bit is `set` if the corresponding bit of
                 // the concrete value is known to be '0'.
}
```

Abstract values are written as a vector of symbols where we use **1** if a given bit is known-one, **0** if a given bit is known-zero and **?** if a given bit is unknown. An example of an abstract value for our known-bits analysis is [1001????], which is stored as the pair (0b10010000, 0b01100000) or, in decimal, (144, 96).

- (i) Briefly describe the concept of abstract interpretation. Particularly, discuss performance tradeoffs that motivate abstract interpretation. [2 marks]
- (ii) Abstract interpretations typically define a value named \perp (bottom), used for uninitialised variables. For the known-bits analysis as introduced above, explain which abstract value you would choose to represent the bottom value \perp . Justify your choice. [2 marks]
- (iii) Define correct and reasonable precise abstraction functions $\alpha(a \ \& \ b)$, $\alpha(a \ | \ b)$, $\alpha(a \ \wedge \ b)$, where $\&$, $|$, and \wedge are bitwise and, or, and xor operators. [7 marks]
- (iv) For x of form [????11??] and y of form [??00????], compute for each variable its maximally precise abstract value.

```
uint8_t foo(uint8_t x, uint8_t y) {
    uint8_t t0 = x * 4; // [.....]
    uint8_t t1 = y >> 2; // [.....]
    uint8_t t2 = t0 && t1; // [.....]
    return t2;
}
```

[3 marks]

- (b) Describe the concept of a peephole rewrite. [2 marks]
- (c) The following C code initialises an array. C array indexing requires a hidden arithmetic operation. Rewrite the loop to optimise it using strength reduction and loop invariant code motion.

```
int i = 0;
while (i < 100) { v[i] = 42; i++; }
```

[4 marks]