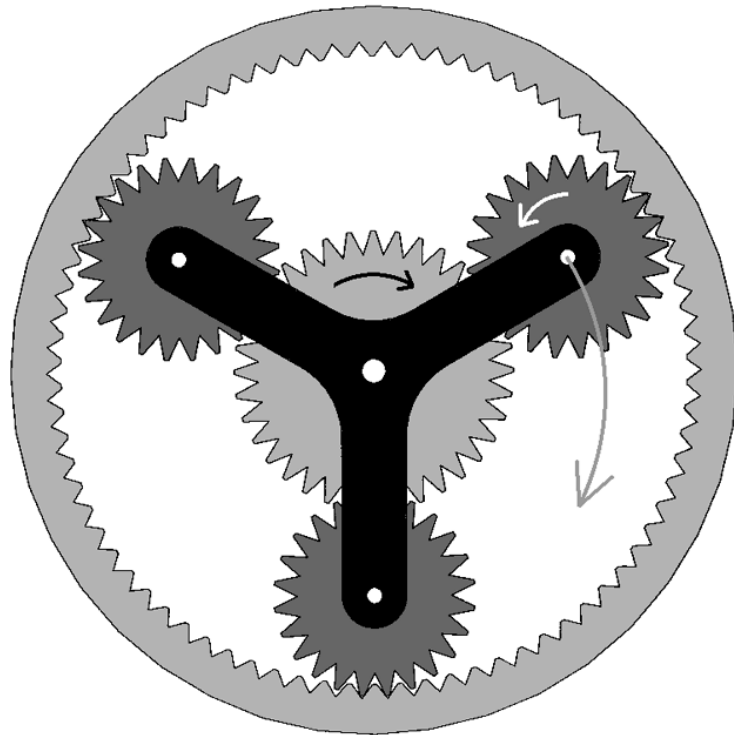


Advanced Software Testing

Integration Testing



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Advanced Software Testing

- ❖ A series of webinars, this one excerpted from *Advanced Software Testing: V3*, a book for technical test analysts, programmers, and test engineers
- ❖ People are very familiar with unit testing
- ❖ People are very familiar with system testing and unit acceptance testing
- ❖ However, integration testing is often the main missing test level
- ❖ What do software professionals need to know about integration testing?



Classic Integration Techniques

- ❖ Classic integration: functional decomposition of hierarchical system
 - ❖ Top down
 - ❖ Bottom up
 - ❖ The sandwich (a combo of top down and bottom up)
 - ❖ The big bang
- ❖ Relies on non-shippable code created by developers
 - ❖ Stubs
 - ❖ Drivers



Classic Integration Algorithm

- ❖ The methodology is intuitive
 - ❖ Build incrementally with unit-tested components
 - ❖ When a failure occurs, suspect the latest-added component
- ❖ Objections to decomposition based integration:
 - ❖ Artificial workflow designed more to help project management than serve the needs of the software development team
 - ❖ Presumes that correct behavior follows from correct units and correct interfaces
 - ❖ Stubs and drivers are expensive to create
 - ❖ Excessive number of builds needed



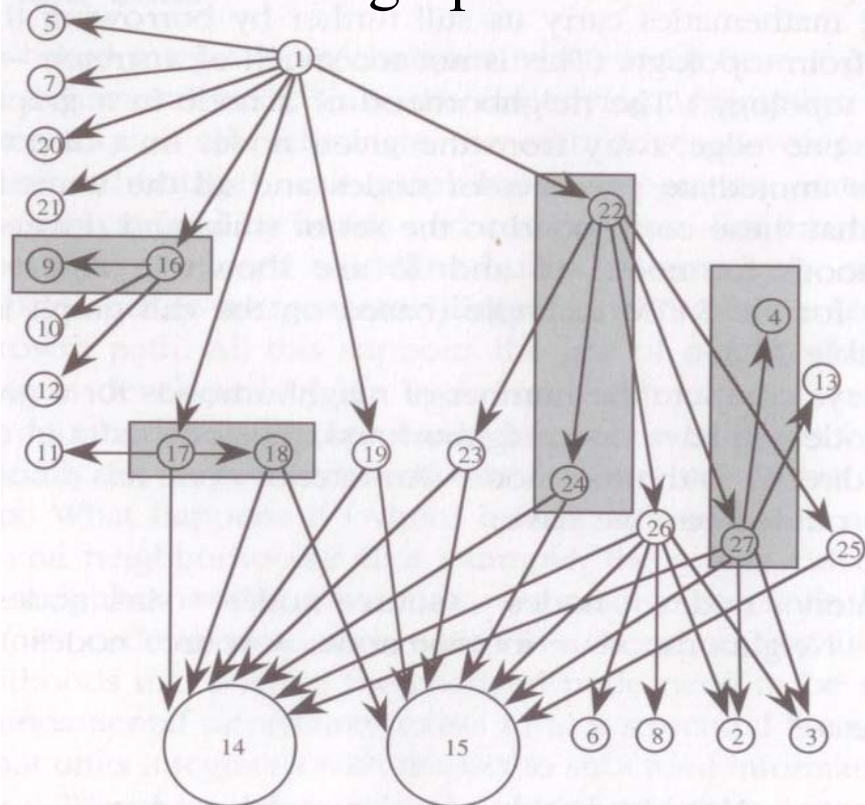
Call Graph-Based Integration

- ✦ Rather than dealing with a fixed hierarchy, this looks at the behavior of groups of modules
- ✦ Reduces non-shippable development
 - ✦ Test with real code rather than stubs and drivers
- ✦ Two basic methodologies use call-graphs
 - ✦ Pair-wise integration: does not reduce number of test sessions needed by much but does reduce stubs and drivers needed
 - ✦ Neighborhood integration: reduces both sessions and drivers and stubs

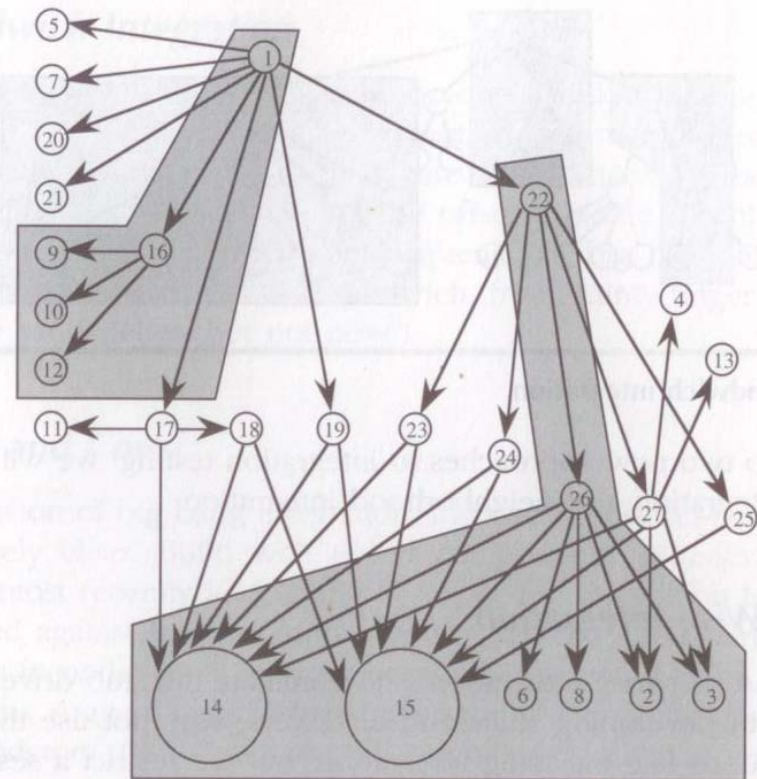


Example: Call Graph Integration

Pair-wise call graph



Neighborhood call graph



-- Graphics from "SW Testing, A Craftsman's Approach" by Paul C Jorgensen 2nd ed.[2002]



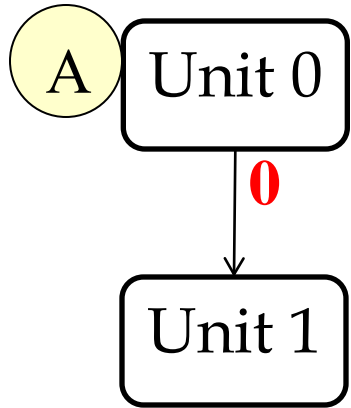
McCabe Integration Basis Paths

- ❖ McCabe complexity theory can also be extended and used for integration testing
- ❖ 4 different caller/callee relationships can exist between modules; any relationships in a system can be represented by one or several of these design predicates
- ❖ Each design predicate has an associated integration complexity; when combined, these indicate how many tests are needed to cover the integration effort
- ❖ Tests to cover the basis paths are called basis tests

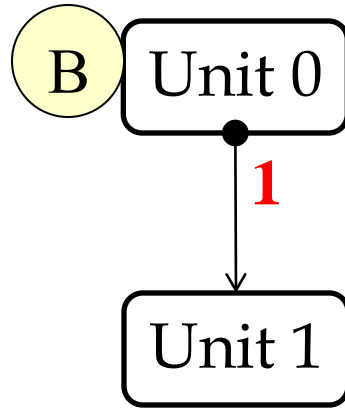


Design Predicates

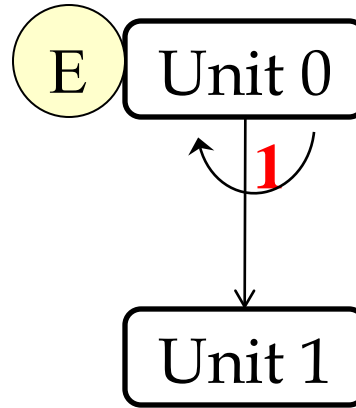
Unconditional call



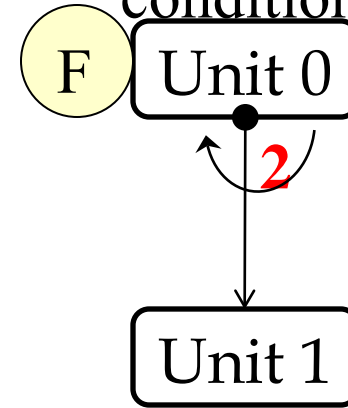
Conditional call



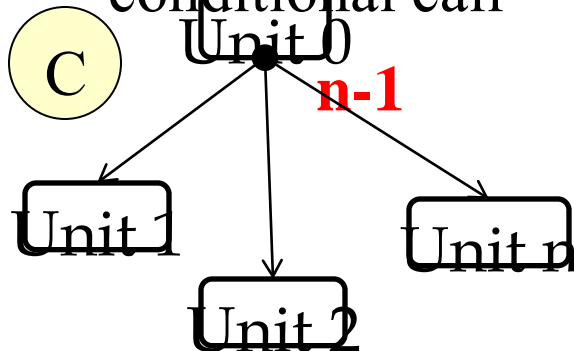
Iterative call



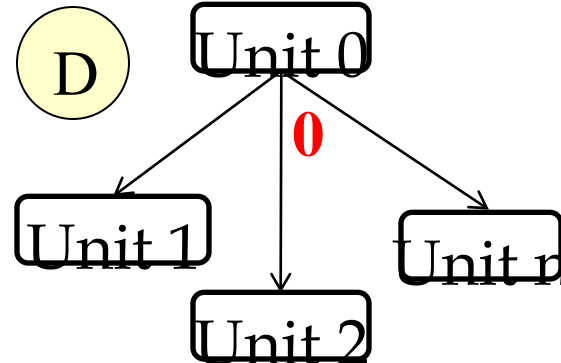
Iterative conditional call



Mutually exclusive conditional call



3 Unconditional calls





```
jmp_buf sjbuf;
unsigned long int hexnum;
unsigned long int nhex;
```

```
main()
/* Classify and count input chars */
{
    int c, gotnum;
    void pophdigit();

    hexnum = nhex = 0;

    if (signal(SIGINT, SIG_IGN) != SIG_IGN) {
        signal(SIGINT, pophdigit);
        setjmp(sjbuf);
    }
    while ((c = getchar()) != EOF) {
        switch (c) {
            case '0': case '1': case '2': case '3': case '4':
            case '5': case '6': case '7': case '8': case '9':
                /* Convert a decimal digit */
                nhex++;
                hexnum *= 0x10;
                hexnum += (c - '0');
                break;
            case 'a': case 'b': case 'c':
            case 'd': case 'e': case 'f':
                /* Convert a lower case hex digit */
                nhex++;
                hexnum *= 0x10;
                hexnum += (c - 'a' + 0xa);
                break;
```

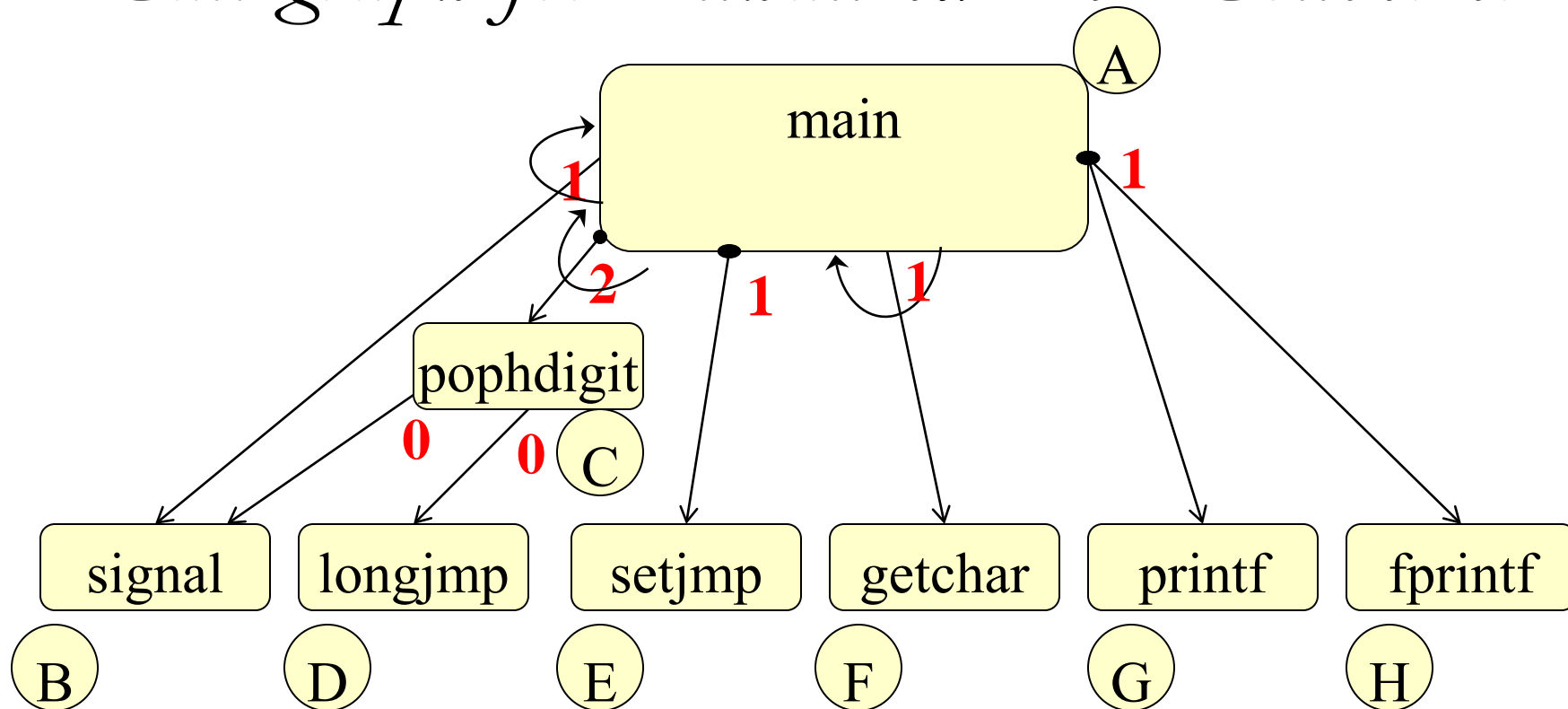
```
        case 'A': case 'B': case 'C':
        case 'D': case 'E': case 'F':
            /* Convert an upper case hex digit */
            nhex++;
            hexnum *= 0x10;
            hexnum += (c - 'A' + 0xA);
            break;
        default:
            /* Skip any non-hex characters */
            break;
    }
}
if (nhex == 0) {
    fprintf(stderr, "hexcvt: no hex digits to convert!\n");
} else {
    printf("Got %d hex digits: %x\n", nhex, hexnum);
}

return 0;
}

void pophdigit()
/* Pop the last hex input out of hexnum if interrupted */ {
    signal(SIGINT, pophdigit);
    hexnum /= 0x10;
    nhex--;
    longjmp(sjbuf, 0);
}
```



Call-graph for Enhanced Hex Converter



Integration Complexity = Sum(Design Predicates) + 1

$$IC = (1 + 2 + 1 + 1 + 1 + 0 + 0) + 1$$

$$IC = 7$$



How Many Basis Tests are Needed?

- ✦ A basis test is a set of inputs and other conditions that force control to flow along a certain basis path
- ✦ Note that several basis paths may be covered in one test: the actual number of test cases is likely to be less than the number of basis paths
- ✦ In this case, the basis paths can be covered in 4 tests
 1. ABBEFFG (input **A**) → “Got 1 hex digits: a”
 2. ABFH (input **EOF**) → “hexcvt: no hex digits to convert!”
 3. ABBEFFFCBDFFFG (input **F5^CT9a**) → “Got 3 hex digits: f9a”
 4. ABBEFFCBDF...FFCBDFFG (input a non-trivial string with lots of Ctr-C combinations) → “Got N hex digits: XXXXXXXX” where N is the number of hex digits that were loaded less the ones removed by the signals



Conclusion

- ❖ This webinar has given an overview of techniques and concepts related to integration testing
- ❖ This test level is often forgotten, but is very important
- ❖ Even in Agile lifecycles, where continuous integration occurs, tests are needed to focus on the interfaces between units
- ❖ Proper integration testing helps prevent late discovering of integration defects during system or acceptance testing



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