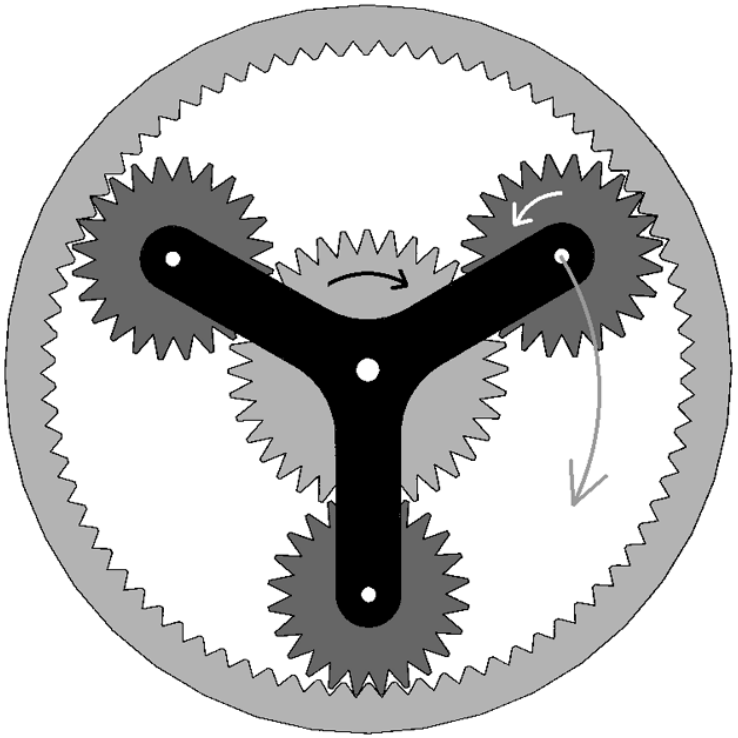
Advanced Software Testing

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

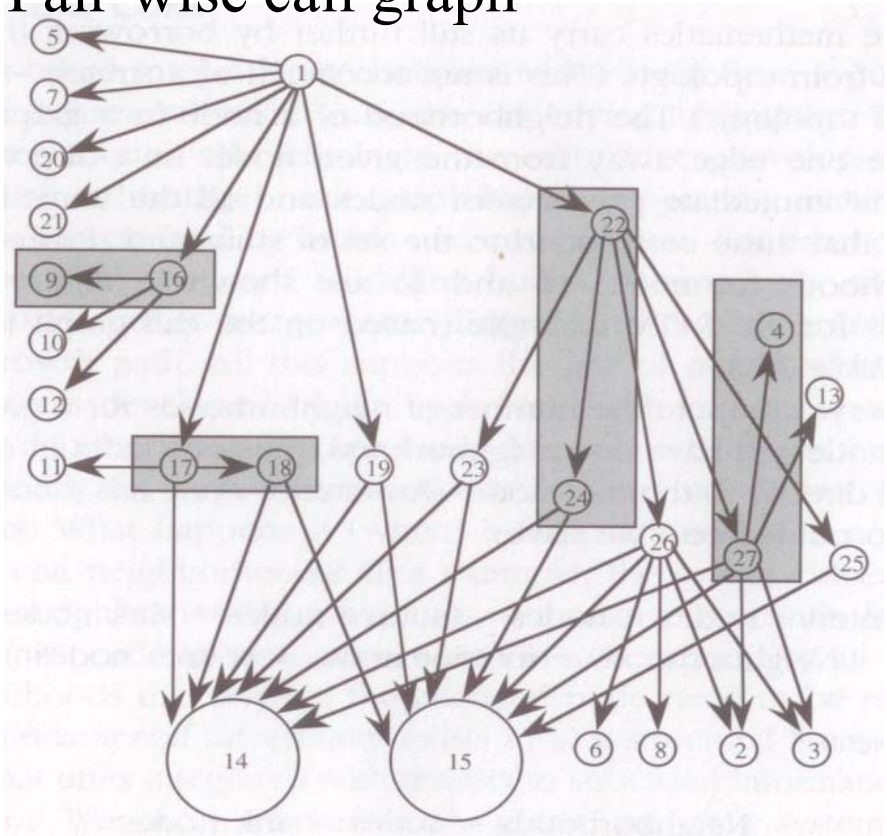
- The methodology is intuitive
  - Build incrementally with unit-tested components
  - When a failure occurs, suspect the latest-added component
- Objections to decomposition based integration:
  - Artificial workflow designed more to help project management than serve the needs of the software development 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

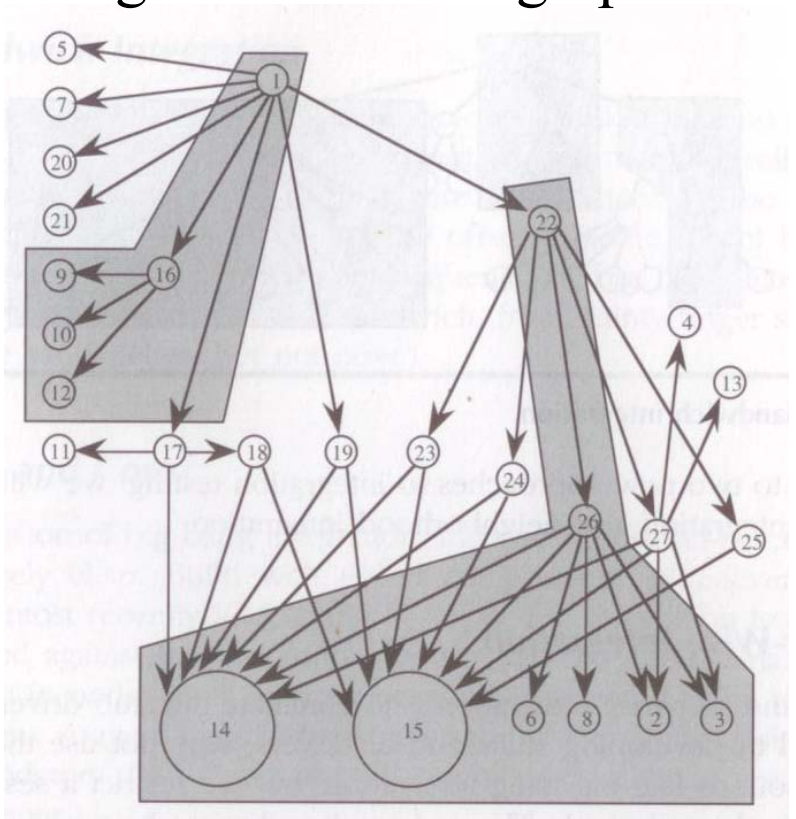
- Rather than dealing with a fixed hierarchy, this looks at the behavior of groups of modules
- Reduces non-shippable development
  - Test with real code rather than stubs and drivers
- Two basic methodologies use call-graphs
  - Pair-wise integration: does not reduce number of test sessions needed by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

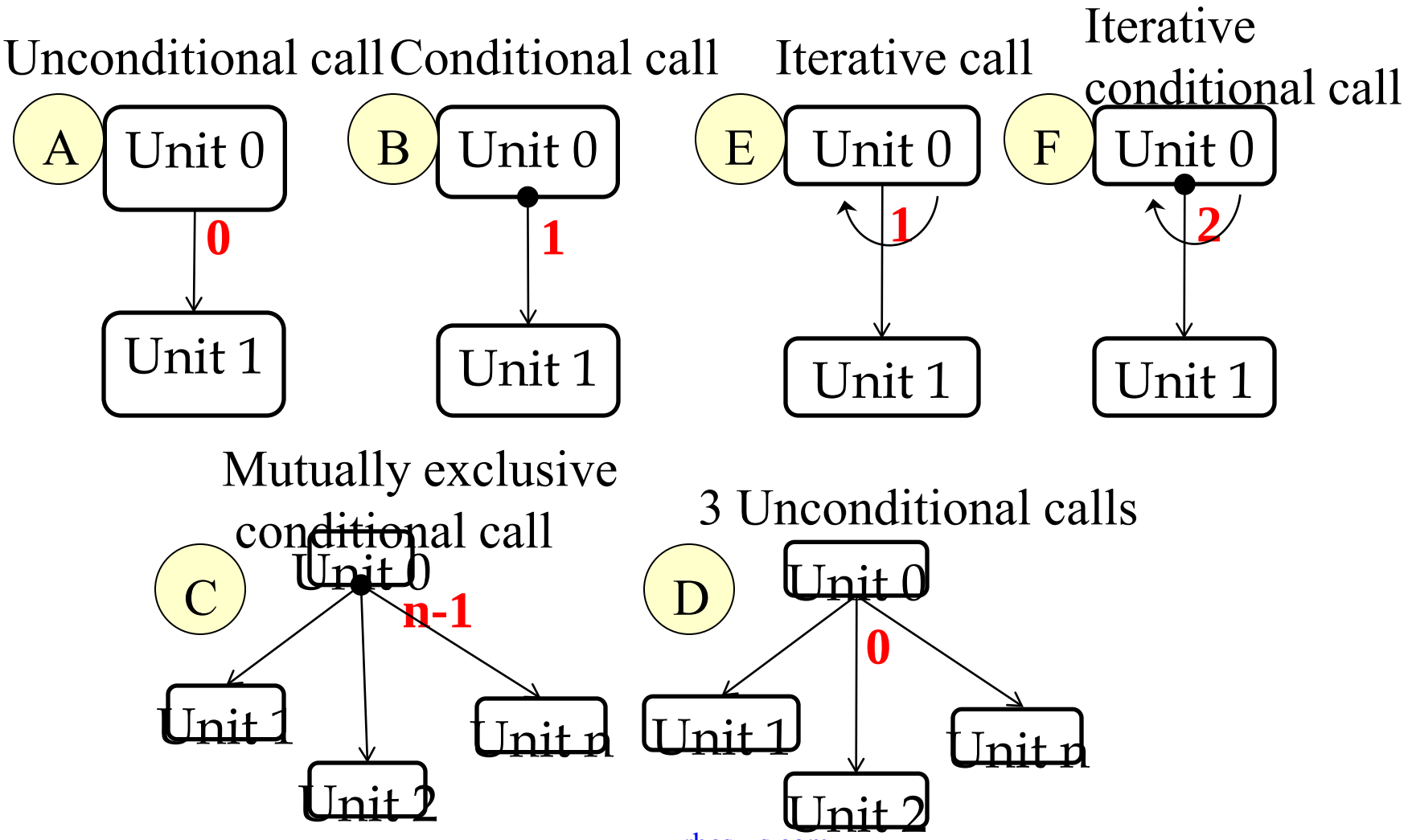


-- Graphics from "*SW Testing, A Craftsman's Approach*" by Paul C Jorgensen 2nd ed.[2002]

McCabe Integration Basis Paths

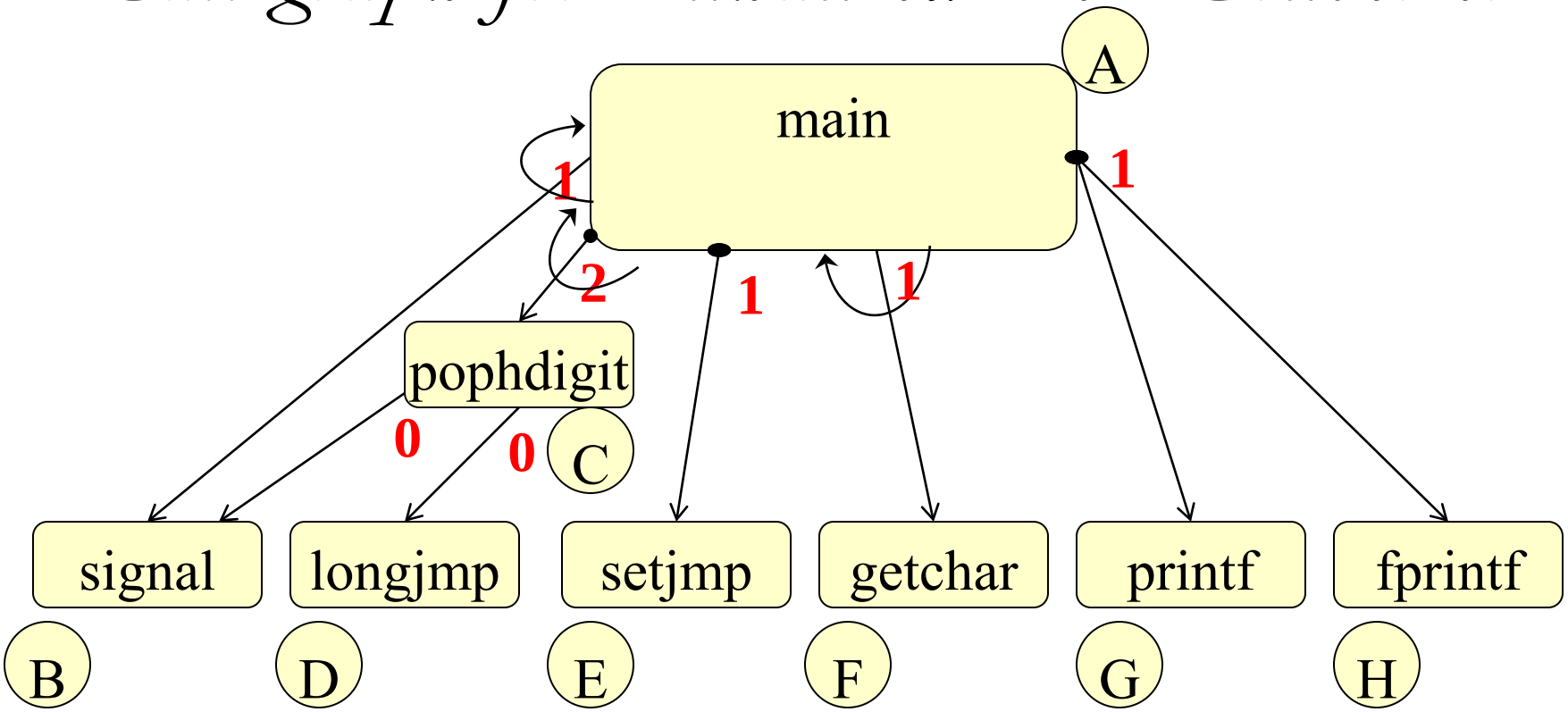
- McCabe complexity theory can also be extended and used for integration testing
- 4 different caller/callee relationships can exist between modules; any relationships in a system can be represented by one or several of these design predicates
- Each design predicate has an associated integration complexity; 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



```
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. ABBEFFCBDFF…FFCBDFFG (input a non-trivial string with lots of Ctr-C combinations) → "**Got N hex digits: XXXXXX**" 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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