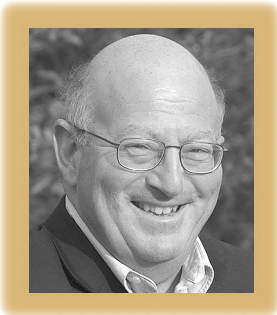
Editor: Martin Fowler ■ ThoughtWorks ■ fowler@acm.org

Agile Programming: Design to Accommodate Change

Dave Thomas

Agile development provides a set of practices simple enough to engage developers, managers, and customers yet sufficiently sound and disciplined to build quality software with predictability (see www.agilemanifesto.org). Applications are expected to evolve over time as their requirements change, and agile development's refactoring and testing practices accommodate software evolution. (Indeed, Extreme Programming's maxim is "embrace change," and today's best developers view refactoring as a badge of honor.)



Refactoring improves code, usually increasing the function while reducing code bulk. However, such refactoring or restructuring often forces the application to undergo a complete development cycle, including unit, acceptance, and regression testing, followed by subsequent redeployment. In a large IT or engineering production system, this can be time consuming and error prone.

Agile programming is design for change, without refactoring and rebuilding. Its objective is to design programs that are receptive to, indeed expect, change. Ideally, agile programming lets changes be applied in a simple, localized way to avoid or substantially reduce major refactorings, retesting, and system builds.

Table-driven programming encompasses four well-known but perhaps forgotten agile-programming techniques that help anticipate and accommodate many common changes.

Table-driven programming

In the early 1970s, systems programmers took great pride in using table-driven programming, much as programmers today might talk about their models or design patterns. It's a proven technique for implementing policy-driven systems, and it uses state pattern matching, concurrency, and workflow; decision tables (business and engineering rules); and constraints (spreadsheets).

Separating policy from mechanism

The principle of separating *policy* (what) from *mechanism* (how) is a best practice in design. A policy-driven system uses a set of rules to describe a specific policy and an associated specialized policy "language" runtime that provides the execution mechanism.

Given a well-designed policy language, an analyst, engineer, or end user can often completely describe the system behavior. This eliminates the potentially expensive and error-prone step of translating from business requirement to implementation.

State tables

Most designers are familiar with simple state tables, state transition diagrams, or regular expressions. The difficulties with maintaining huge state machines found in large complex mission-critical applications led to the

0740-7459/05/$20.00 © 2005 IEEE

breakthrough development of state charts,[1] which brought modularity to state tables. The combination of state charts and objects produced several powerful variations called *object charts*. UML provides object charts, which are unfortunately a little more complex than many applications need.

State tables are most commonly used for validating input sequences, for simple parsing and event processing in user interfaces,[2] and for managing asynchronous concurrent communications events. Unfortunately, far too many user interface designers fail to appreciate the state space's complexity, hard coding the state model rather than designing and implementing a proper state transition model. State tables are used in engineering for process control and in business for complex workflow.

Decision tables

Few developers are familiar with decision tables—one of the simplest and most powerful techniques for dealing with complex logic. A decision table is unique in that an end user can easily specify and maintain it. The table comprises a set of conditions placed above a set of actions to perform (see Table 1).

For each combination of conditions (c1, c2, …), a rule exists (r1, r2, and so forth). Each rule comprises a Yes, No, or Don't Care (–) response and contains an associated list of actions (a1, a2, and so forth). Then, for each action, an action sequence number specifies the order in which an action should be performed if this set of conditions is true. For example, if c1, c3, c4, and c5 are all true, then a1 should be followed by a3.

This simple table format makes it easy for end users to specify the conditions, actions, and rules. Users needn't worry about complex nested `if then else` statements or be confused by `and/or` when describing complex logic. Additional tables can be automatically checked to determine if rules are redundant or ambiguous.[3] Finally, an `else` rule either traps all unspecified cases, or the cases trigger an exception. Designers can decompose very complex logic into multiple tables, which invoke other tables as actions.

I've applied decision tables in domains from embedded real-time systems to library loans, and I'm always amazed that the users can diagnose the problems and often repair them without developer intervention! David Parnas has discussed the use of tableaus of a similar nature in formal documentation for mission-critical systems such as nuclear reactors.[4]

Table 1

A decision table, comprising a set of conditions and a set of actions to be performed

		Rules				
	Conditions/actions	r1	r2	r3	r4	Else
Condition stub	c1	Y	N	Y	N	–
	c2	–	Y	–	N	–
	c3	Y	N	N	N	–
	c4	Y	–	N	N	–
	c5	Y	Y	Y	Y	–
Action stub	a1	1	2	–	3	–
	a2	–	1	–	1	2
	a3	2	3	2	–	–
	a4	–	–	1	2	1

Spreadsheets

Many policies exist that users can conveniently express in a simple spreadsheet using their favorite desktop tool. These policies can be used daily to define everything from salaries and benefits to drill-holes for engine blocks. This makes spreadsheets a natural tool for defining policies. Executing them using a spreadsheet tool is straightforward, provided you apply some discipline—such as remaining consistent with the naming and layout.

Few developers are familiar with decision tables—one of the simplest and most powerful techniques for dealing with complex logic.

Implementation

A generator can help automatically translate policies into Java, C#, or C++, as is currently done for UML state and message sequence charts. However, for many years, developers have been translating policies into tabular data structures and then evaluating them using a simple interpreter.

This latter style of table-driven programming has important advantages. First, because the policy is represented as data, developers and sometimes end users can change it on the fly and use it to support mission-critical nonstop applications. Second, the tables and interpreter require substantially less space than the compiled representation. The cost of interpretation is minimal for 90 percent of applications whose performance is dominated by other factors.

Clearly, being able to test and manage tables is important. Developers can apply user-centered testing tools such as FitNesse (http://fitnesse.org/FitNesse.WhatIsFitNesse) to the tables, and the tables can be stored in the configuration management system and managed along with the application code. Furthermore, because the tables are represented as data, you can easily modify them using maintenance transactions or table editors and deploy them in the application as soon as the next transaction.

The ability to dynamically reconfigure applications will become increasingly important as businesses evolve into real-time distributed enterprises. There's no more agile business than

one that can change its business policies, test, and redeploy without recompilation or reloading.

State tables have obvious implementations as a 2D array, which can be represented as a sparse array for very large tables. Object charts can have subtle semantics, so I generally recommend using a well-designed evaluator.[1]

In the case of decision tables, my favorite implementation is the *rule mask technique*,[3] a compact and efficient interpreter. Tables are represented compactly as bit vectors and a simple interpreter that uses bit operations. This implementation also provides a simple technique for definition time checking of conflicts or ambiguities.

Spreadsheets can be parsed with a simple parser that records the dependencies such as *c11 needs a11 and b11 to compute a11 + b11*. The simple constraint system is easily solved by sorting the dependencies using a topological sort.[5] Clearly, if special formulas or macros exist, you need to provide the equivalent action code. To evaluate the spreadsheet, you walk the sorted dependency table in order, evaluating each element.

From the outset, agile development focuses on accommodating program evolution. It's important in design to consider those points of the system that will likely undergo substantial change. At such points, it's often appropriate to apply agile-programming techniques.

Software designed using older table-driven techniques is often far more portable and malleable than equivalent human- or machine-generated code. Because it's much easier to change data than code, data table representations allow programs to be changed on the fly, often by end users!

References

1. M. Samek, *Practical Statecharts in C/C++*, CMP Books, 2002.
2. R.C. Martin, J.W. Newkirk, and B. Rao, "Taskmaster: An Architecture Pattern for GUI Applications," *C++ Report*, vol. 9, no. 3, 1997, pp. 12–14, 16–23; www.objectmentor.com/resources/articles/taskmast.pdf.
3. P.J.H. King, "Conversion of Decision Tables to Computer Programs by Rule Mask Techniques," *Comm. ACM*, vol. 9, no. 11, 1966, pp. 796–801.
4. D.L. Parnas, J. Madey, and M. Iglewski, "Precise Documentation of Well-Structured Programs," *IEEE Trans. Software Eng.*, vol. 20, no. 12, 1994, pp. 948–976.
5. D. Knuth, *The Art of Programming*, Addison-Wesley, 1973.

Dave Thomas is cofounder of Bedarra Research Labs (www.bedarra.com) and the OpenAugment Consortium (www.openaugment.org), and an adjunct professor at Carleton University and the University of Queensland, Australia. He's also a founding director of AgileAlliance.com and founder of Object-Technology International (www.oti.com). Contact him at dave@bedarra.com; www.davethomas.net.