**Problem Statement**

Implementation of the behavior of a pacemaker described in the Pacemaker requirements document by Boston Scientific, with the need for demonstrating:

- **Utility**: pacemaker performs useful actions;
- **Safety**: it doesn’t perform harmful actions.

**Background**

A pacemaker is a device that’s placed under the skin of the chest or abdomen to help control heart arrhythmias. Depending on which arrhythmias are present, modern pacemakers provide different functioning modes that perform different kinds of therapeutic behavior.

The goal of the project is to build a simple but complete implementation of a subset of the pacemaker’s function modes.

- **AAT**: Atrium chamber paced
- **VVI**: Ventricle chamber paced
- **DDD**: Both chambers paced

**Solution**

The artificial pacemaker is a system whose behavior needs to be accurately and completely specified in order not to lead to possible mistakes.

Our approach made extensive use of formal methods: pacemaker properties formalized by means of the TRIO+ language for the specification of the system, and validated through the use of the SAT checker called Zot and the specification and verification system called TVS (TRIO/PVS).

Starting from the natural language specification of the pacemaker, a TRIO formal specification was produced. ZOT and PVS were used to validate the initial formal specification. These tools are complementary. ZOT automatically checked the satisfiability of the system, and produced example behaviors that were useful in understanding the axiomatization. Then PVS was used to prove the target properties of the system. Each time a new axiom was introduced, the validation process was repeated.

Finally, the Design of the system followed directly from the TRIO formal specification.

**Implementation**

For the purpose of this project a JAVA simulation of the pacemaker system was implemented. The simulation allowed the project to proceed on time and is sufficient to represent most of the aspects of the pacemaker problem.

Given as input the desired parameters of the heart, and the set of pacemaker parameters, the program produces an ECG that shows how the pacemaker regulates the behavior of the patient’s heart.

**Conclusions**

The resulting pacemaker performs well on the provided test cases and could be used by a physician to explore how the pacemaker reacts to different heart behaviors.

The big advantage of formal methods and of the tools used is that they help us to develop a complete understanding of the system we are designing. This has a cost in terms of time, but then the implementation phase is straightforward and less prone to errors.