SOFTWARE MEASUREMENT:
WHY A FORMAL APPROACH?

Norman Fenton
Centre for Software Reliability
City University
London, UK

Abstract

As a discipline software measurement has suffered from a fragmented approach and a lack of a rigorous foundation. We show that the observation of some very simple, but fundamental, principles of measurement can have an extremely beneficial effect in the field of software measurement. Simply interpreting the formal definition of measurement in the software context leads to: (i) rationalizing and relating the various diverse software metrics activities, (ii) practical help in constructing and validating software measures, and (iii) the exposure of inconsistencies of some existing approaches in software measurement.

Any measurement involves an obligation to identify the entities of interest and the attributes of these to be measured. In software the entities may be classified as products, processes, and resources, while the attributes may be classified as internal or external to the entities. Next comes an obligation to determine whether measurement is being used for assessment or prediction.

We look at some well-known approaches to software measurement within this framework, exposing both the good points and bad points. We also describe the relevance of measurement theory to software measurement.
1 Introduction to measurement

1.1 Measurement in everyday life

Measurement lies at the heart of many systems which govern our lives. Measurements in economic systems determine price and pay increases. Measurements in radar systems enable us to detect aircraft through clouds. Measurements in medical systems enable the diagnosis of specific illnesses. Measurements in atmospheric systems are the basis for weather prediction. Without measurement, technology could scarcely have begun.

But measurement is not solely the domain of professional technologists. We all use it in everyday life. We can calculate the total bill in a shop to make sure we are given the right change. We can measure the height of our children to make sure we buy the right size clothes. When we go on a journey by car, we can work out how far we will be travelling by using a map, and then use this to predict how long the journey will take (since we can measure our speed on a speedometer), or how much petrol we need to buy.

1.2 What is measurement?

The examples we have mentioned make up a varied collection of measurement activities. What is it that they all have in common? How do we define the process of measurement? The formal definition is:

Measurement is the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to clearly defined rules.

So measurement is concerned with capturing information about attributes of entities. But what does all this mean? An entity may be an object, such as a person or a room, or an event such as a journey or the testing phase of a software project. The attribute is the feature or property of the entity which we are interested in, such as the height or blood pressure (of a person), the area or colour (of a room), the cost (of a journey), or the time (of the testing phase). Thus it is wrong to say that we 'measure things' or that we 'measure attributes'; in fact we measure attributes of things. It is ambiguous to say that we 'measure a room', since we could measure its length, area, or temperature. Equally it is ambiguous to say that we 'measure the temperature', since we measure the temperature of a specific geographical location under specific conditions.

Measurement assigns numbers or symbols to these attributes of entities in order to describe them. Hence when we are measuring the heights of people we will always assign bigger numbers to the taller people, although the numbers themselves will differ according to whether we use metres, inches, or feet. The number is a useful and important abstraction. If we have never met Hermann but are told that he is 7 feet tall, then we can imagine how tall Hermann is in relation to ourselves, and we will know that he will have to stoop when he enters the door of our house.

Many people think that measurement is a clear-cut concept. In fact there are many different authoritative views about it, which lead to different interpretations about what is and what is not measurement. This leads to many difficult questions which need to be answered. For example:

- We noted above that colour was an attribute of a room. In a room with blue walls, is 'blue' a measure of the colour of the room?
- We all agree that height of people can be measured, but what about intelligence as measured say by an IQ test score? Or wine quality measured by ratings of experts?