Exploration and Real Options as an Analogy for Software Development

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Introduction

Being a Petroleum Engineer myself and a registered Professional Engineer (TX 78591), as well as a software developer, I have had mixed feelings about comparing software development to engineering. The problem that I see is that most analogies compare software development to construction or manufacturing. While some of these analogies have validity, I find far more similarities to the field of petroleum engineering, particularly the exploration and production of petroleum reservoirs. While construction and manufacturing are dealing with the optimization of deterministic or knowable issues, both software development and petroleum engineering deal with issues that are both unknown and often unknowable.

An oil and gas explorer has at any state a number of options from which to choose. These options are very much like "real options" as used in the financial world in that there is an option, but not an obligation to take action. Often, the explorer may invest in obtaining data (e.g. seismic) which will provide some *value of information*. The *value of information* can sometimes shed light on some unknown issues, but often there are still issues that are unknowable or for which the cost of obtaining information would be prohibitive. For those issues it may be better to choose or invest in a path which provides flexibility in dealing with unknowns, thereby receiving some *value of flexibility*. Software development can also benefit from these "real options" concepts.

Oil and Gas Exploration and Production

The search for oil and gas has evolved over the years, in much the same way that software development has evolved. In the early years oil was discovered by lone wildcatters, while software was developed by coding cowboys.

Oil and gas deposits are normally found in reservoirs in the space between the grains in underground sedimentary rock such as sandstone or limestone. Reservoirs may be anywhere from the surface of the earth to a depth of five miles. "Seeing" through the rock on top of a reservoir is not easy, and makes the process of finding oil and gas reservoirs highly uncertain. When investigating a new area, geologists and geophysicists investigate and attempt to reconstruct the geological history of an area to determine if it is a likely candidate to contain oil or gas. One of the most common approaches is to acquire seismic data, roughly analogous to an x-ray of the earth.

Once an area is determined to be a potential source of oil and gas, an exploratory well is drilled to confirm the presence of hydrocarbons. If well is dry, then the project is abandoned. Unfortunately 9 out of 10 exploration wells end with this fate. On the other hand, if the exploration well hits pay dirt, then the oil company has a "real option" as to how or if to

develop the reservoir. It is a real option, because the oil company has a right, but not an obligation to develop the reservoir. Yet there is often considerable uncertainty surrounding the financial viability of the reservoir.

Value of Information and Value of Flexibility

There are two primary means of coping with uncertainty: information and flexibility. In some circumstances it is possible to reduce uncertainty by gathering more information. In other situations it is better to create flexibility in order to postpone having to deal with the uncertainty. These are often referred to as the *value of information* and the *value of flexibility*.

After the successful exploratory well has been drilled, the engineer must decide how to size the facilities for handling the oil. This will be largely a function of the size of the reservoir. He could get more seismic data to get a slightly better picture of the underground reservoir, i.e. *value of information*), or he could build a flexible handling system which could grow should the reservoir turn out to be large (*value of flexibility*). If the cost of the acquiring the seismic information exceeds the cost of "buying" flexibility by building a flexible handling system, then he would be better off to build in the flexibility and would have no need to acquire the seismic data. A similar example comes from a different kind of drilling. The dentist could be quite flexible, and drill every tooth until she determined if it had a cavity, or she could utilize the value of information and take x-rays to determine if any drilling should be done at all.

Geosteering: The Agile Oil Company

Oil companies face some challenging problem when drilling, particularly when drilling into a new frontier. In Figure 1 below, the seismic data has indicated a possibility of an oil reservoir "B". The problem with seismic data is that even though recent advances have enabled 3D-seismic, the 3rd dimension is seismic time (i.e. the time it takes for a charge to travel from the surface to the reservoir and reflect back to the surface receiver. See Figure 1 for a crude picture of seismic reflection.). To get to something useful for a driller, this seismic time needs to be converted into a real depth. The difficulty lies in that this requires knowing something about the rock properties of "A", which until it has been drilled through can only be estimated.

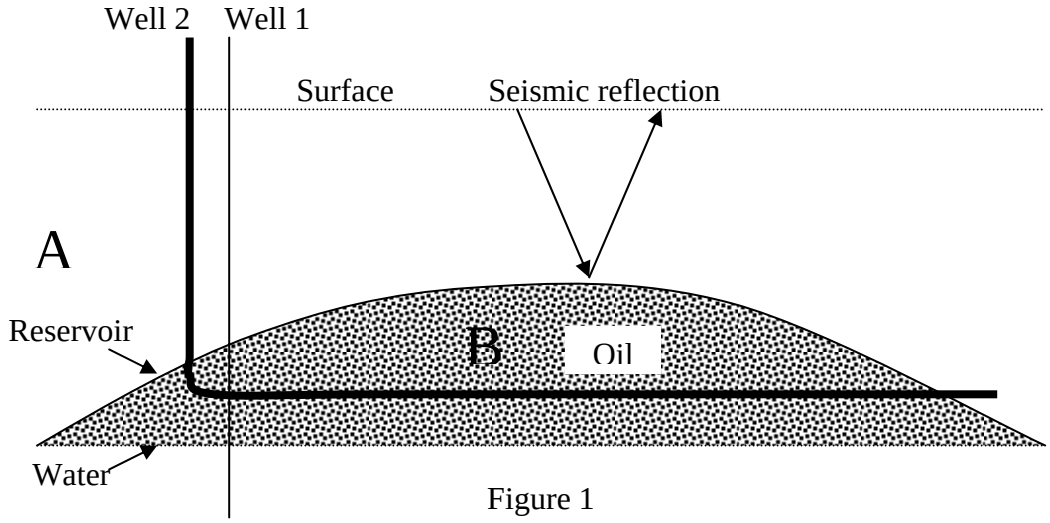

Figure 1

In the past, this was not a huge problem because most wells were drilled nominally vertically though the reservoir like Well 1. New improvements in drilling technology enable more complex wells that can be horizontal like Well 2. These wells can be much more efficient since they have much more surface area contact with the reservoir.

What if the assumption about the properties of rock "A" are wrong? As can be seen in Figure 2, Well 1 can be drilled without much consideration. However, if Well 2 is drilled as planned, then it will miss the actual reservoir area entirely. Oil companies have realized this and have coined the term "geosteering" to describe the process of updating the drilling path based on the new real time information collected about area "A". The resultant is Well 2', which started as Well 2, but has been steered so that it now intersects with where the reservoir really is rather than where it was assumed to be.

In this case, conformance to original plan would mean a dry hole. Instead we have steered the well to meet the actual position of the reservoir. The original plan was not bad; it was based on the best estimate that we had for the properties of "A". Further planning and science could not have improved our estimate of "A"; its real properties are fundamentally unknowable until we start drilling.

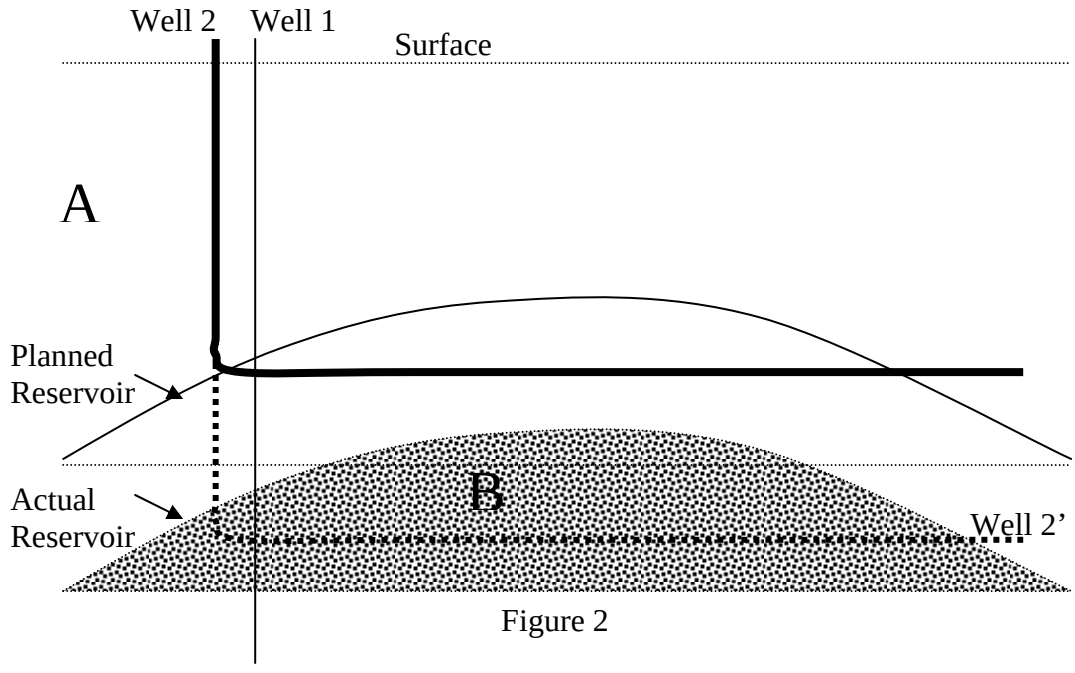

Figure 2

So What about Software Development?

I look at the analogy between petroleum exploration and software development as follows:

Oil and Gas Exploration	*Software Development*
Find prospects	Explore Ideas, Research
Drill exploratory well	Prototype
Build facilities	Architectural Framework
Begin production	Ship!
Drill more wells	Enhancements
Manage and maintain reservoir	Maintenance
The Reservoir	The market

The real value of the analogy to petroleum exploration is the realization that software development could benefit from viewing development activity as a "real option." At any stage of the development process, the team has a number of options or paths that they can choose to take in order to develop the product. If they live in wonderland, and everything is known and predictable, then the options are rather meaningless because all choices are obvious. More likely, however, wonderland is more like Lewis Carroll's Wonderland, where the only thing that is certain is that there is plenty of nonsense.

Most software development projects have uncertainties that are very much like the order of magnitude of uncertainty that is faced in petroleum exploration. For many years the petroleum engineering field has tried to deal with this using more complex deterministic engineering techniques. To that extent, the field has relied heavily on the *value of information* in order to cope with the uncertainties. This is much like the software engineering approach to big design up front. Both the petroleum field and the software development field are beginning to realize that no matter how much effort is invested in information, there are still significant uncertainties that must be dealt with. Agile software development approaches exploit the inherent *value of flexibility* that enable just in time decisions that focus on maximizing the value for the software at the time it will be shipped.

Real Option	*Software Development*
Value of Information	Planning or prototyping to expose unknowns prior to making a larger investment.
Value of Flexibility	Investing in enabling flexibility in the system so that it will be capable of dealing with an unknown future environment. Software development has inherent flexibility in that many decisions can be delayed until some point in the future. XP tries to make sure that the cost of change is low by ensuring comprehensive automated unit tests.