Our Orthodox Methods and Tools Are 100 Years Old and Due for Replacement

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Abstract This paper is intentionally provocative. The analysis methods and specification tools we use today are derived from the century-old Taylorism via office work-study. If that was our scientific foundation, many obvious anomalies should have forced us to find a new paradigm. Rejecting *information-flow* in favour of a *knowledge-field* paradigm, we can build a rigorous science of organisational semiotics to underpin the engineering of information systems, taking account of the essentially human and social aspects of information: semantics/meaning, pragmatics/intention and social products/value, while reaching the level of rigorous formality needed for the technical aspects of the system. Practical case studies have demonstrated the advantages of this new approach, which reduces costs, especially over a long period while making the system easier for the users to understand.

1 INTRODUCTION

We need a sound scientific foundation for engineering organisational information systems that encompasses the organisational as well as the technical.

How do we compare? Hardware evolves phenomenally fast; software less so; and, 60 years on, AI still threatens, like Shakespeare's King Lear, to "do such things, what they are, yet I know not; but they shall be the terrors of the earth." As an example, Stephen Hawking told the BBC: "The development of full artificial intelligence could spell the end of the human race." But we are slower still. IS systems analysis and design clings to Taylor's 100-year-old scientific management. Today's UML, looks modern but it embodies the same old ideas.

1.2 Machines

UML, 1960s' ISAD tools and Taylor's 1890s work-study tools all track the flow of parts and materials and sequences of operations performed on them. Usually, in factories these are mechanical products, but in offices, documents and in computer systems, structured data. Taylor's science concerns only the movements of and operations upon objects and materials. So, importing his science into our domain limits 'information science' to some purely technical aspects and forces us to treat every organisation as a kind of machine.

Is that enough? Probably not!

1.3 Organisations

Back in the 1960s, the steel industry had an acute shortage of systems analysts, and they asked me to create courses to address the problem. Computer manufacturers providing the only other training at that time, taught how to introduce computers into a business. That technical bias and lack of understanding of the human and social aspects of information systems seemed to explain the alarming project failure rate. We should be equally alarmed today because the failure rate is still high.

1.4 Mystical Fluids

Instead, hoping to teach how to improve an *organisation* as an information system, using technology where appropriate, I searched for a scientific understanding of the role information plays in the functioning of organisations. To start with,

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scientific language must denote things precisely. But to understand "information" were we offered a hierarchy of mystical fluids – data> information> knowledge>wisdom – each distilled from its predecessor in a chemical engineering metaphor. Even in the 1960s I was scornful of this idea, except as an imaginative point of departure[1]. Without a terminology with precise operational meanings, we cannot conjecture testable hypotheses from which to formulate theories for understanding and predicting the behaviour of systems employing that wonderful, new economic resource: information.

2 SIGNS AND SEMIOTICS

"Information" is a useless primitive concept; it has so many different meanings. Armed with the criterion "Take me to see some." I searched for a better primitive (Stamper, 1973). And there it stood: the sign. Semiotics (Nöth, 1990), the study of signs takes its name from the ancient Greek for a symptom (the sign of a disease), which must be something physical. From its roots in philosophy, semiotics has an extensive literature that few were bothered to read. John Locke (1690) had identified the "doctrine of signs" as the bridge between the physical and social worlds: our technical and organisational domains. Signs are things standing for other things that we want to communicate about. So, to displace DIKW's four mystical fluids, I wrote a book about information as a number of precisely defined properties of signs, all of them capable of empirical investigation. Three categories of them are well established in the literature[2], but I drew attention to two others[3] and added the social products of using signs to form a "semiotic framework" to divide an empirical science of organisational information into distinct areas of investigation. Incidentally, it serves as a checklist when working on any information system because, to be effective, it must function correctly on all six levels.

There is nothing mystical about signs. They always have a physical form, which may be investigated empirically in different ways, as indicated in this table. Technical properties do not depend on any human agent whereas the others always involve signs in relation to individuals or communities.

2.1 A Broader Focus

Can this broader understanding of information help us to improve upon the disgraceful track record for project failure? Every enterprise is coy about failures, so figures are very difficult to obtain, but trawling the web, as I last did in 2012, suggests, roughly speaking, that 25% succeed, 50% fail to meet functional requirements, budget or timing, while 25% are totally written off: a disgrace! Will a broad, unifying, scientific foundation help to eliminate or reduce those failures?

Each technical branch of semiotics has its own scientific support. Physics underpins hardware engineering; statistics and probability theory support work on the empirics of signs; while the formal sciences of logic and mathematics, as adapted by computer science, deal with the syntactic aspects of signs. Those excellent foundation disciplines tempt us to retreat into the safe hands of software engineering, well away from the messy domains of human and social behaviour. But the problems of engineering software for computers differ fundamentally from those of engineering information systems for organisations, unless you treat organisations as though they were computers with various information fluids flowing through them.

SEMIOTIC FRAMEWORK		semantics of "information"
Human Information Functions (neglected)		
	SOCIAL WORLD: norms, law, culture, attitudes, values, beliefs commitments,	*norms*
EFFECTIVENESS	*PRAGMATICS*: intentions, communications, conversations, negotiations	*sign-tokens*
	SEMANTICS: meaning, signification, denotation, connotation, validity, truth-falsehood	*sign-types*
	Technical Platform (dominant)	
	SYNTACTICS: formal structure, logic, language syntax, software, data, files	*sign-types*
EFFICIENCY	*EMPIRICS*: pattern, variety, noise, entropy, channel capacity, redundancy, efficiency codes	*populations of sign-tokens*
	PHYSICAL WORLD: signals, traces, hardware, speed, energy and material consumption, info economics	*sign-tokens*

A software engineer need not differentiate between a game about dungeons and dragons and a system affecting the lives or livelihoods of real people. Ensuring the safety of an atomic power station or providing social security for a population entail problems of meaning, intentionality and the social value of the signs. Only in relation with

[1] DIKW comes from TS Eliot's 1934 poem, *The Rock*. Science may start from imaginative ideas but must develop them with criticism and imaginative tools of other kind. However, a scientist who has access to poetic ideas gives me more confidence than one of constrained imagination.

[2] Eg: Syntactics, semantic and pragmatics in the writings of Charles Morris (1946) and CS Peirce (1931-35).

[3] CS Peirce included their physical properties and Colin Cherry (1957) their statistical properties.

those properties. Working on the analysis and design of an enterprise, with or without a computer application, one must deal rigorously with the real world (not formal) meanings of all the data, the intentions they express, and the agents who bear responsibility for their personal and social effects.

2.2 A Unifying Science

Organisational information systems engineering needs a unifying scientific discipline. To the technical branches of semiotics we must add appropriate treatments of semantics, pragmatics and the social properties of signs *but also with the essential precision and formality for our work*. Whereas the Taylor's 100 year-old tools serve the technical domains, they do not help us with meanings, intentions or the social properties of information, unless one counts adding informal comments to the documentation. The challenge is to clarify the essential human and social concepts and handle them in precise formal terms. Until we have without a rigorous science behind us, one that deals with organisations as well as computers, we shall continue to work on organisations as skilled artisans like the craftsmen who built early Rolls Royce cars, but unable to keep pace with change because organisations as they evolve to equate with Rolls-Royce aero-engines

2.3 Phases of Scientific Progression

How can we move forward? Thomas Kuhn (1970) has shown that science progress in two ways: in a Normal phase, while everyone works on a set of problems determined by a fixed paradigm with its dominant metaphor, taught from similar texts, until anomalies undermine the shared body of theory and a revolutionary phase is precipitated. Taylor's late 19th century techniques dominate our education and our practice but its anomalies are only beginning to disturb a few of us. Perhaps we imagined that fundamental changes were taking place while all we had were continuous, incremental adaptations of Taylor's methods and tools, via O&M of the interwar years, their adaptation for computer systems, followed by numerous modifications by software engineers that were unified in UML; but, beneath the surface, the old ideas remained in place.

Let us call to mind some of those anomalies, They include: an appalling project failure rate; persistence of sloppy ideas such as DIKW, inadequate treatment of meaning and intentionality, a weak understanding of how information delivers any value; high cost of system maintenance; obscure documentation that prevents an organisation's management from exercising control over projects; obscure mountains of documentation that make it difficult to involve an organisation's members from contributing to a system's design and development; a long lead time before a project can deliver benefits; and so on. Where is our scientific motivation?

If we had a serious scientific tradition and noticed that so much is wrong, we should be out on the proverbial streets in protest. Which makes me suspect that a lack of scientific spirit in the Information Systems community is holding back progress. Below I show that the comments of programme committee for another conference that expose their unawareness of scientific method and their responsibility to apply it.

My position is that it is time for a scientific revolution in our field. It is time for a new dominant metaphor and a better paradigm. Why doesn't everyone share my disquiet?

2.4 Resistance to Change

Perhaps Kuhn's explanation is enough: people who have expended decades acquiring expertise in some orthodox methods, for which they are hired at comfortable salaries, react against the threat of having to learn another way of working. Certainly, when consultancies build computer applications that need their expertise to maintain them, they benefit from a long-term, reliable cash flow; if all their competitors work within the same antiquated paradigm, their government and industrial clients have no alternative but to buy similar orthodox-style products from another consultancy. So why upset the boat? Those who teach the long-established orthodoxy react in a similar manner.

New ideas that threaten a comfortable way of life will nearly always come from a rather isolated maverick, so the opposition is easily attacked. When Max Planck's quantum theory encountered this treatment he said that science progresses one funeral at a time. We may feel great sympathy for him but should acknowledge the difficulty we all encounter when adopting a new paradigm.

So, having called for a revolution, I shall do something that you will probably consider even more foolish: I assert that there is a radically better paradigm for our work that can vastly improve our tragically bad project failure rate and it is based on a more suitable metaphor, one that embraces both the technical and the social aspects of the engineering problems we are required to solve.

3 CONJECTURE AND REFUTATION

Of course, I express myself this way to provoke you to attempt to falsify my risky assertion. Why? Because my research team and I adopted Karl Popper' scientific method of Refutationism: science progresses by bold imaginative leaps that formulate new universal hypotheses that must be expressed precisely enough to be capable of falsification by even a single particular empirical observation or experiment although no proof of a universal hypothesis will result from any number of particular empirical tests. In order that I may learn, I invite your criticism.

When the courses I established for the steel industry became the basis for the UK's national programme run by the British Computer Society and the National Computing Centre, I became an academic at the London School of Economics and my chance to apply a radically new paradigm had arrived.

3.1 A New Paradigm

Instead of the information flow paradigm, I adopted a different metaphor from physics: *field* instead of *flow*. It became rather obvious when examining the computerisation of the Department of Health and Social Security. I noticed that a single shelf for books could house all the Acts of Parliament and Statutory Instruments containing the legal norms defining what that huge organ of state must do. Only a minority of the legal norms governed routine bureaucracy and only some were worth automating. If we could express that small percentage in a suitable formalism, a computer might be able to interpret them, in effect turning the legal norms into the programs for supporting computer applications. The actual procedure was to translate the 1m shelf of legislation into library of 400 thick volumes of "clerical codes" that were then translated in orthodox flow specifications.

In addition to the legal norms, the people involved in the health and social security work also make use of the numerous social norms belonging to their shared background knowledge. So we recast our task: to define the knowledge people in this activity domain must share if they are to collaborate in an organised way.

Knowledge (note this precise definition) consists of social norms (culturally evolved informally as well as enacted as legal norms by Parliament) that express what things they deal with (perceptual norms), how that world functions (conceptual norms), how to judge things (evaluative norms) and how to act in different situations (behavioural norms). This knowledge field binds together the community involved into a system or institution that governs how they collaborate on the relevant, shared activity.

3.2 Refutable Hypotheses

That broad idea led to the evolution of

F: a formalism that can express any of the norms in question; and

P: a program to interpret the formalised norms
Conjecturing a version of F and its associated version of P, the research proceeded iteratively by pitting F and P against bodies of norms of increasing complexity, until they failed, as a result of which learned enough to make improved versions of F and P. The scientific investigation never ends because the latest hypotheses always invites attempts to refute them, but one may apply the formalism and interpreter as soon as they seem acceptable for an engineering task.

4 RESULTS

We have achieved more than we initially hoped for and we have been able to test the results on innumerable desktop case studies but only two substantial actual organisational applications. (From the point of view of the refutationist method, we should be attempting many such real applications but the opportunity to do so is not readily offered by businesses that, contrary to all the propaganda, are seldom entrepreneurial enough to take any risk.)

4.1 Two Business Applications

Case-I: University AdministrationIn one country, we built their administrative system (A) using our methods and tools for the first time and, over ten years, compared it with a corresponding system (B) in a different country in the same region. B employed modular software of orthodox design, perfected on 200+ similar applications worldwide. System-A was bespoke and did all and exactly what the organisation required; system-B, on the other hand, forced the organisation

- to change to suit the available software and/or
- to pay for additional expensive software modules and/or
- to have clerical staff process data in the margins of printouts.

Such solutions make adaptation to changing requirements even slower, and more costly. Over ten years, the comparative costs for System-A were [I hesitate to say this, lest I be disbelieved] 80% lower than for System-B. Adapting to changing requirements was quick, easy and cheap, turning a sclerotic organisation into an agile one. Moreover, because everyone found System-A easy to understand, experienced users with detailed knowledge could contribute to the design and on-going improvement of the system. Additionally, the sound theoretical foundations of our methods meant that many desirable feature were inbuilt whereas orthodox systems, must treat them as optional extras at additional cost: a full historical database; explicit semantic structures and associated error detection; specification of responsibilities; traceable records of all error treatment; multi-lingual facility (English and one other language but any number of others could be added easily).

Case II: A Complex Expert System - This system was being developed using the best of orthodox methods but was on the point of being totally written off because the experts commissioning it could not understand what was being constructed for them. The orthodox documentation had grown to its usual gargantuan volume; with its impenetrable style, the experts could not understand much of it; it was boring to read and difficult to verify. So they invited two members of our team to apply our methods.

The documentation shrank to about one-twentieth of its original volume. The expert commissioners found the new formalism succinct and easy to read. They could see what the system designers were proposing and were able to steer the emerging system toward their goals. Implementation went through smoothly and successfully,

4.2 Criteria of Progress

You may not think that I have described anything resembling a revolution in our scientific field. That is exactly the right attitude. Refutationism demands permanent scepticism on the part of its practitioners. Despite that, Popper advises one to conjecture "bold hypotheses" that shift one's perspective in a surprising way. Better still they should preferably:

- explain as much as the hypothesis it is intended to replace;
- do so more succinctly,
- replacing a large obscure model with one that is simpler and easier to understand; and
- in a way that explains more about the domain;
- preferably bringing to light new invariants in the domain; while
- raising new, exciting lines of enquiry and application

4.3 Success? or Not yet?

The question: does the "knowledge field" paradigm achieve all that?

Given an organisation specified as a knowledge field, any number of suitable information flows can be derived from it but not the reverse.

Case II achieved a massive reduction in the documentation while making it easier to understand, thus reversing the plan to write off the project;

- a flow model tells you a lot about boring bureaucratic activity whereas the field model tells one what should happen for business reasons, especially who is responsible and mostly why; it contains a semantic model, it accounts for human intentions and, by showing the intended changes of attitudes, deals with the valuable products of the information;
- the semantics for the domain are contained in a Semantic Normal Form that is largely invariant over time and between cultures; the classification of norms enables one find a stable organisational kernel that remains invariant over all bureaucratic revisions that do not change the essential business activities;
- the computer-interpretable specification opens up a range of organisational research opportunities and practical products such as a touchstone to test any new computer application; with a Parliamentary Counsellor we have tested the method for legal drafting and parallel design of supporting software; it leads to ERP solutions based on 'atomic' modules; etc. etc.

5 SCIENTIFIC CRITICISM WELCOME

In conclusion, I present my position to you and explicitly ask for your critical questioning. In the best scientific tradition, I want you to take my request seriously and make your comments rationally and, therefore, capable of rational response. Recently, from another conference, the reviewers of my paper made unhelpful comments that were:

- value judgements to which no rational response was possible; or

- assertions that a statement or explanation is wrong or questionable without even a hint of why; or
- complaints that I did not cite their favourite authors who, in fact, we had read but found irrelevant to our work; or
- complaints about missing explanations that were actually in the text; while others
- complained that I had relied on their appropriate prior knowledge to keep my explanations to a length appropriate to a book rather than a conference-length paper;

This made me sceptical about our community having a well-established scientific tradition. If one, as a scientist (PC member, for example) writes a criticism of a scientific document, then one has a duty to abide by the same standards of discourse we impose on the authors.

Now is the time for some refutations! I hope I have provoked you into having interesting discussions. It would be unwise of colleagues younger than me to be so controvertial but I have reached a point in life when worrying about my future career would be pointless. Have fun!

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