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Web-based Systems Development: Analysis and Comparison of Practices in Croatia and Ireland

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Abstract: The "dot.com" hysteria which sparked fears of a "Web crisis" a decade ago has long subsided and firms established in the 1990's now have mature development processes in place. This paper presents a timely re-assessment of the state of Web development practices, comparing data gathered in Croatia and Ireland. Given the growth in popularity of "agile" methods in the past few years, a secondary objective of this research was to analyse the extent to which Web development practices are guided by or otherwise consistent with the underlying principles of agile development.

1. Introduction

A decade ago, the sudden and frenetic growth of the newborn World Wide Web caused considerable apprehension within academia. Murugesan et al [20] spoke of "a pressing need for disciplined approaches and *new* methods and tools", while Oinas-Kukkonen et al [22] claimed that "systematic analysis and design methodologies for developing Web information systems are necessary and urgently needed among practitioners". Thus began a flurry of academic activity that became known as the "Web Engineering" movement, and many methods and techniques specific to Web/hypermedia design were proposed (see [19]).

During the peak years of the Web Engineering movement (circa 1998 to 2002), a substantial number of empirical studies of Web-based systems development were published in the academic literature. However, very few studies of commercial Web design practices have since appeared. After the abatement of the pre-Y2K "dot.com" hysteria, there ensued an industry shake-up whereby many of the firms engaging in shoddy or casual practices were found wanting and did not survive. Development technologies have advanced substantially in recent times, and many Web development firms originally established in the mid- to late-1990's have at this stage attained process maturity. It is therefore a timely juncture to once again look at the state of Web development practices a few years on.

Within systems development in general, there has been a shift of attention in recent years to the new wave of "agile methods", a loosely related family of development approaches which are underpinned by the values and principles of the "Agile Manifesto" (www.agilemanifesto.org). Unlike the aforementioned Web/hypermedia methods, these agile approaches originated not from academia but rather from professional communities of practice. They emerged as a reaction to the inflexibility of the so-called "plan-driven" or "document-driven" development approaches which came to prominence in the "methodologies era" of the 1970's and 1980's. While the rate of adoption of "pure" agile methods in industry is still relatively low [3], [24], we suspect that many Web developers are using their own in-house hybrid approaches which, even if not directly informed by the principles of the Agile Manifesto, share similarities with methods such as eXtreme Programming, Scrum, or DSDM. With regard to general software development practices, such was indeed the finding of Hansson et al [14]. One of the objectives of this paper is therefore to review Web development practices and developers' attitudes and assess how they correspond with the "agile" philosophy.

2. The software industry in Croatia and Ireland

Since the inception of the ISD international conference series in 1988, one of its primary aims has been the exchange of scholarly knowledge between the western and eastern nations of Europe. Consistent with this tradition, this paper compares Web development practices in Croatia against those of Ireland. Apart from the literature on globally-distributed software development (e.g. [10], [21]), there are relatively few studies which compare and contrast systems development practices in different countries. Cusumano et al. [9] performed an interesting analysis of general software development practices across various geographic regions, but specifically in the area of Web development we know of only two studies that compare experiences between different nations [2], [13].

Table 1. Global Information Technology Report 2007/2008: Head-to-Head

Variable	Croatia	Ireland
High-tech exports (% of total exports)	3.65%	20.75%
Secure Internet servers (per 1 million inhabitants)	48	420
Personal computers (per 100 inhabitants)	19.42	52.99
Internet bandwidth (mB/sec per 10,000 inhabitants)	10.37	59.97

Source: http://www.insead.edu/v1/gitr/wef/main/analysis/headtoheadint.cfm

Croatia and Ireland are both small European countries with similar populations (4.4 and 4.2 million respectively). Both nations experienced turmoil in the process of gaining independence, but in Croatia the consequent period of recovery was

much more recent with the result that, as yet, Croatia lies behind Ireland in terms of key economic/ICT indicators (Table 1). As a result of judicious targeting of foreign investment from the mid-1980's onwards, most of the world-leading ICT companies established plants in Ireland and it developed into a major centre for software development [5]. Ireland's "Celtic Tiger" economy spawned hundreds of indigenous software companies in the 1990's, leading to comparisons with California's "Silicon Valley" [7]. The Irish ICT sector had a turnover of €63.5 billion in 2005, representing 22% of national turnover in industry and services [8]. The Croatian ICT industry is newer than in Ireland but is growing at a rate of 18% per annum, supported by strong inward investment. There are now over 1,400 companies in the sector with about 23,000 employees (compared to 82,000 in Ireland). Overall, the Croatian ICT sector contributes 5% to national GDP. Though there is not yet the same presence of foreign multinationals as in Ireland, this is increasing, with companies such as Microsoft, IBM, Hewlett-Packard, Oracle, SAP and Ericsson now having bases in Croatia [1], [15]. Croatia can therefore be regarded as a progressive but as yet developing nation in terms of its ICT sector, so it is interesting to compare Croatian Web development practices against those of Ireland.

3. Research Method

This research set out to answer the questions:

- *RQ1. What processes and methods are used by Web developers in practice?*
- *RQ2. What if any essential differences exist between Web development practices in Croatia and Ireland?*
- *RQ3. How do Web development practices correspond with the general principles of "agile" methods?*

In Ireland, a dual-mode (postal and Web-based) questionnaire was initially distributed to a purposefully selected sample of 438 organisations. Follow-up qualitative interviews were then conducted with Web developers in 13 organisations. Meanwhile in Croatia, an extended Web-based adaptation of the Irish questionnaire was circulated to 418 companies.

Conducting surveys across different countries presents a number of methodological challenges [18]. As Webster [26] explains, "a bias or error inherent in any given [research] method may interact with differential factors in each country so that the results will not be comparable". Both surveys used a similar research design. In neither country did a readily available register of Web development companies exist, so the respective samples were compiled by searching various business directories. The Web sites of all organisations were then visited to ascertain if they were likely to be involved in the types of development activities we were interested in. The Irish sample excluded all companies which appeared to be engaged mainly in the production of simple "brochureware" Web sites (see [19]).

The Croatian sample was not as restrictive in its selection, though care was taken only to include legitimate registered businesses (further reported in [23]). Both the Irish and Croatian surveys had comparable item response rates. No discernable differences in response tendencies were evident, except where one open-ended question on the Irish questionnaire was substituted by a drop-down list on the Croatian questionnaire.

Table 2. Profile of survey respondents

	Croatia	**Ireland**
Organisation size	N = 101	N = 167
1 – 10 employees	81 (80.2%)	95 (56.9%)
11 – 50 employees	12 (11.9%)	33 (19.8%)
51 – 250 employees	7 (6.9%)	9 (5.4%)
> 250 employees	1 (1.0%)	30 (18.0%)
Respondent background	N = 101	N = 167
Software development	36 (35.6%)	55 (32.9%)
Visual / graphic design	36 (35.6%)	44 (26.3%)
Miscellaneous	29 (28.7%)	68 (40.7%)
Respondent experience	N = 99 mean: 7.1; median: 7.0	N = 161 mean: 6.1; median: 5.0
Less than 2 years	3 (3.0%)	2 (1.2%)
2 to 4 years	12 (12.1%)	54 (33.5%)
5 years or more	84 (84.9%)	105 (65.3%)

Though problems with linguistic equivalence are always prone to occur in international surveys, the fact that the second author, who is fluent in Croatian and English, personally translated the questionnaire means that the likelihood that any such errors arose is greatly reduced. Coverage error was not an issue either in Ireland or Croatia because multiple sources were used to compile the sample, and all survey participants had access to the distribution channels. While the Irish software industry arguably has a headstart on Croatia, the significance of the timelag factor (i.e. "temporal equivalence") is moderated here because the Croatian survey was conducted almost four years after the initial stage of the Irish study.

The SPSS data sets from both studies were re-coded into a combined data file, with a total of 268 usable responses (167 from Ireland, 101 from Croatia). Mann-Whitney tests were then run to compare the two data sets. Significant differences were revealed for organisation size ($p < .001$), respondent experience ($p < .01$), and background discipline ($p < .05$). As can be seen in Table 2, there was a higher concentration of large organisations in the Irish sample than in Croatia (most of these were multinational IT or financial services companies). On the whole, the Croatian respondents had a few years more experience than the Irish respondents, but this can be explained by the timelag between the execution of the two studies. The Croatian sample had a higher proportion of visual designers, whereas the Irish

sample had a larger number of "miscellaneous" respondents who could not be clearly placed into either the "software development" or "visual design" camps.

4. Findings and Discussion

4.1 Small Development Teams and Collective Knowledge

Both in Ireland in Croatia, it was found that most Web design teams are small, typically comprising five or less members (Table 3), with Croatian teams tending to be slightly smaller ($p < .01$). Where teams consist of just a few co-located close-knit workers, intra-group communication problems are lessened and can be more easily resolved [17]. Not surprisingly, both groups therefore responded that communication within design teams caused few problems. It should be noted that in the Croatian sample, most of the companies are small (80% had 10 or less employees) so development teams were therefore also bound to be small. However, in the Irish sample, where there are many large companies, it would seem that teams are actually kept small on purpose. As one Irish respondent remarked, "project management skills are the most lacking; keeping a team small is the best way to control the chaos".

Table 3. Size of development teams

	Croatia	Ireland
Size of development teams *	N = 87 mean: 3.4; median: 3	N = 166
1 developer	12 (13.8%)	9 (5.4%)
2 – 4 developers	57 (65.5%)	96 (57.8%)
5 – 10 developers	15 (17.2%)	51 (30.7%)
> 10 developers	3 (3.4%)	10 (6.0%)

* Mann-Whitney $p < .01$

Small teams also have the advantage that they can share knowledge and expertise more readily, which are key factors in high-speed development environments because they contribute to greater productivity and better decision-making. As later elaborated, it was found (Table 6) that the development processes of many organisations, though clear, are not explicitly articulated. The question therefore arises as to how new recruits acquire a sense of "the way we do things around here". The obvious explanation is that, because Web development teams are generally small, shared understandings are easier to build and team members can more readily learn by virtue of working in close proximity to each other. Indeed, when asked to rate the level of usefulness of different sources of design knowledge, both the Croatian and Irish developers indicated that "observing or consulting experienced colleagues" is most useful. The literature suggests that as teams become larger,

there is a greater need for formalised processes and procedures. Conversely, "lighter" methods may be better suited to small teams because traditional "heavy-weight" methods are unduly cumbersome [6], [25]. Our findings uphold this generalization: in both countries it was found that as team size increased, there was a greater propensity to use documented guidelines and procedures.

4.2 Project Management and Requirements Management

Most projects (Croatia 80.6%; Ireland 62.8%) are delivered in 15 weeks or less with a typical delivery time being of the order of 3 months (Table 5). It therefore seems that the so-called "3 x 3" profile [12] typifies Web-based systems development in both Ireland and Croatia, – teams of about 3 developers working to deliver a project in about 3 months. In spite of these short release cycles, we found that "Web time" development pressures are regarded as a major problem by very few respondents (Croatia 2.3%; Ireland 4.3%), and that mostly there are no or only minor problems in controlling project tasks and managing team collaboration (Croatia 69.9%; Ireland 76.2%). The most acute problem for the Irish respondents was the old classic: controlling project scope / feature creep. This was not quite as much an issue for the Croatian developers, whose stand-out biggest problem was "coping with volatile and changing requirements" (Table 4). A difference ($p <$ .001) was revealed here between the two groups, suggesting that the Irish cohort are better at managing requirements changes. One explanation for this emerged from interviews where it was found that phase "sign-offs" is a very common practice in Ireland, whereby a detailed requirements specification is produced and "frozen" before commencing full scale production. If requirements subsequently change the client must bear the cost, thus forcing them to prioritise requirements according to value-added. In contrast, the use of requirements specifications is not as common in Croatia (Table 5), a difference that is significant ($p < .001$).

Table 4. Problematic issues in project management and requirements management

Issue / Extent of problems experienced		**None**	**Minor**	**Moderate**	**Major**
Coping with volatile and changing requirements **	Croatia N = 93	1.1%	10.7%	43.0%	45.1%
	Ireland N = 164	1.8%	38.4%	46.4%	13.4%
Preparing accurate time and cost estimates *	Croatia N = 93	11.8%	25.8%	46.3%	16.2%
	Ireland N = 156	3.8%	43.6%	45.5%	7.0%
Controlling project scope / feature creep	Croatia N = 87	11.5%	25.3%	52.9%	10.3%
	Ireland N = 161	1.2%	39.1%	42.8%	16.8%
Controlling and coordinating project tasks	Croatia N = 93	26.9%	43.0%	26.9%	3.3%
	Ireland N = 164	11.6%	64.6%	20.7%	3.0%
Coping with speed of Web development cycles	Croatia N = 84	25.0%	39.3%	33.3%	2.4%
	Ireland N = 140	13.6%	55.7%	26.5%	4.3%

* Mann-Whitney p < .05; ** Mann-Whitney p < .001

Given their difficulties managing volatile requirements, it is not surprising that the Croatian respondents also had significantly (p < .05) greater problems preparing accurate time and cost estimates. Nevertheless, project managers in both countries seem to be faring reasonably well in this regard. It was found that most projects (Croatia 68.8%; Ireland 65.9%) are delivered within the agreed budget and though only about a third of projects (Croatia 39.3%; Ireland 32.2%) are actually delivered on time, time or cost over-runs of more than 50% are relatively few (Croatia 22.7% and 12.6% respectively; Ireland 16.8% and 2.6%).

Table 5. Comparison of project management metrics

	Croatia	**Ireland**
Project duration (weeks) **	N = 72 5% trimmed mean: 10.8 median: 6.0	N = 140 5% trimmed mean: 14.3 median: 10.5
Variance in project duration *(actual – planned)*	N = 66 5% trimmed mean: 33% over median: 25% over	N = 137 5% trimmed mean: 27% over median: 21% over
Variance in project costs *(actual – planned)*	N = 32 5% trimmed mean: 2% over median: 0% (on target)	N = 76 5% trimmed mean: 4% over median: 0% (on target)
Use of requirements spec. ** Yes	N = 87 48 (55.2%)	N = 163 143 (87.7%)
Size of requirements spec. ** *(number of pages)*	N = 47 5% trimmed mean = 12.9	N = 124 5% trimmed mean = 40.7

** Mann-Whitney p < .001

Table 6. Formality of development practices

	Croatia	**Ireland**
Development process *	N = 101	N = 165
Clear process, explicit	23 (22.8%)	69 (41.8%)
Clear process, but not explicit	63 (62.4%)	69 (41.8%)
No clear process, not a problem	7 (6.9%)	14 (8.5%)
No clear process, is a problem	8 (7.9%)	13 (7.9%)
Use of guidelines and procedures	N = 94	N = 167
Yes **	35 (37.2%)	114 (68.3%)

* Mann-Whitney p < .05; ** Mann-Whitney p < .001

4.3 Development Processes and Procedures

Both groups overwhelmingly responded that they have clear development processes (Croatia 85.2%; Ireland 83.6%), but the extent to which the process is ex-

plicitly documented differs, with a significantly (p < .05) greater proportion of the Irish sample having a written-down process. Similarly, a substantially higher percentage of Irish Web developers use documented guidelines and procedures (Croatia 37.2%; Ireland 68.3%). The percentages of respondents who indicated that they used guidelines and procedures for the following purposes are: requirements documentation (Croatia 22.8%; Ireland 63.5%), technical design (Croatia 22.8%; Ireland 49.7%), project planning (Croatia 24.8%; Ireland 62.9%), system testing (Croatia 19.8%; Ireland 39.5%), interface design/usability (Croatia 26.7%; Ireland 50.9%), and coding practices (Croatia 23.8%; Ireland 34.7%). The existence of documented procedures and guidelines may suggest a certain degree of formality, but we found that in most organisations that have them in place, they are loose or moderately prescriptive rather than stringent. The role of procedures and guidelines therefore seems not to be an attempt to codify design knowledge but rather to serve as a checklist or high level roadmap. This interpretation is held up by an analysis of the additional qualitative data we gathered. In general, though process documentation in many cases is rather comprehensive in so far as there are guidelines to cover most aspects of development, our findings indicate that this documentation is typically lean and of the form of "how-to" pages.

Table 7. Use of development methods and approaches

Type of method / approach	Croatia N = 101	Ireland N = 78	Overall N = 179
Hybrid or customised in-house method	53 (52.5%)	18 (23.1%)	71 (39.7%)
Object-oriented development approaches	37 (36.6%)	6 (7.7%)	43 (24.0%)
Rapid or agile development methods	29 (28.7%)	13 (16.7%)	42 (23.5%)
HCI / Human Factors Engineering methods	27 (26.7%)	6 (7.7%)	33 (18.4%)
Traditional "legacy" software development methods and approaches, or variant	16 (15.8%)	17 (21.8%)	33 (18.4%)
Incremental or evolutionary approaches	17 (16.8%)	10 (12.8%)	27 (15.1%)
Project management methods (e.g. PRINCE2)	20 (19.8%)	4 (5.1%)	24 (13.4%)
Approaches focused on software quality *e.g. ISO9001, CMM*	18 (17.8%)	3 (3.8%)	21 (11.7%)
Web/hypermedia methods *e.g. RMM, OOHDM, WSDM, WebML*	12 (11.9%)	4 (5.1%)	16 (8.9%)

In the Irish questionnaire, survey participants were presented with an open-ended question that invited them to outline whatever Web development methods and approaches they had used. The responses were then coded into the categories shown in Table 7. On the Croatian questionnaire, this question was not open-ended, but rather a list of drop-down items seeking the extent of usage of the same re-coded method categories as had been revealed by the Irish survey. This difference in questionnaire format may in part explain the observed variation in response patterns between the two samples. In particular, the level of reported usage of

Web/hypermedia methods (e.g. WSDM, WebML) is surprisingly high in Croatia compared to Ireland. We acknowledge that there is a margin for error with this particular question, owing to the known differences in response tendencies for list items as opposed to open-ended questions [11]. Nevertheless, the response category "Hybrid or customised in-house approach" has a clear lead ahead of all the others both in Croatia and in Ireland. Our qualitative data provided evidence to suggest that these in-house work practices have evolved out of reflective evaluations of recurrent challenges and constraints encountered within previous projects. The interpretation that in-house methods and approaches are the outcome of reflective practice and continuous process improvement is further supported by the finding, in response to a separate question, that "Learning-by-doing on real projects" is regarded as one of the most useful sources of design knowledge by both Irish and Croatian respondents.

4.4 Attitudes towards documented plans

In both samples (Table 8), nearly all respondents (Croatia 96.8%; Ireland 92.7%) agreed that "to combat system complexity and time pressure, plans are essential". However, in a separate question that measured the level of agreement with the statement that "plans and working methods should be explicitly documented" (Croatia 61.9%; Ireland 79.4%), it was revealed the Croatian developers are significantly less convinced about the need for *documented* plans than the Irish contingent ($p < .001$). A similar disparity of opinion was found in reaction to the statement that "ad hoc improvised methods generally result in systems of poor quality", with a significantly greater proportion of the Croatian respondents disagreeing with this assertion. Of the Croatian and Irish respondents who disagreed with this statement, 24 (68.6%) and 17 (48.6%) of them respectively had earlier indicated that their organisation has a clear though not explicit development process. This suggests that in some cases developers are engaging in the sort of behaviour which Ciborra [4] calls "smart improvisation", – situated problem-solving based on knowledge and competencies.

Table 8. Opinions about Web-based systems development

Issue		Disagree	Neutral	Agree
To combat system complexity and time pressure, plans are essential	Croatia N = 94	1.1%	2.1%	96.8%
	Ireland N = 165	1.2%	6.1%	92.7%
To ensure effective teamwork, plans should be documented **	Croatia N = 92	17.4%	20.7%	61.9%
	Ireland N = 165	7.3%	13.3%	79.4%
Ad hoc improvised methods generally result in systems of poor quality **	Croatia N = 93	37.6%	21.5%	40.8%
	Ireland N = 153	23.5%	7.8%	68.6%

** Mann-Whitney $p < .001$

5. Conclusions

Overall, the findings of our research indicate that, in general, Web development practices in Croatia and Ireland are systematic and guided by purposefully designed processes and procedures. It is notable that, regarding our RQ1, the most popular development approach is to use customised/hybrid methods, whereby Web developers assemble fragments of textbook methods and distill the most useful elements into a home-cooked approach which is then tailored to the needs of each project. The analysis of our qualitative data (further reported in [19] and [23]) revealed that these in-house methods typically blend together the phases of the classical waterfall model with aspects of newer rapid/agile approaches and influences derived from graphic design, marketing, and industrial design/HCI. While 23.5% of respondents made direct reference to their use of "agile" methods, our suspicion that many more organisations are using approaches founded on values and principles similar to those of the Agile Manifesto was confirmed by data gathered in the two surveys and the Irish interviews. Evidence of the manifestation of "agile" principles in common Web development practices provides the answers to RQ3 and can be summarised as follows:

- **Deliver working software frequently:** Web development is characterised by short project cycles and the use of rapid development tools.
- **Emphasis on valuable software:** In Ireland, it is common practice to insist that clients sign-off on a prioritised list of requirements. Subsequent change requests are separately costed, which forces clients to consider value-added.
- **Emphasis on "light" documentation:** We found that development guidelines and written-down processes are often in place, but they generally take the form of loosely prescriptive "how to's" rather than step-by-step procedures.
- **Most effective communication is face-to-face conversation:** Web development is characterised by small teams working in close proximity. The most useful source of knowledge is learning from colleagues.
- **Sustainable pace, and concern for employee morale/welfare:** Streamlined processes, reliable project estimation techniques, and standardised ways of working together not only minimise waste but also reduce the need for overtime and facilitate the equitable division of workload.
- **Collective code ownership:** In both countries, but moreso in Ireland, we found evidence of the use of coding standards and an emphasis on simplicity and re-usability, the rationale being that if a team member is unavailable or if there is a requirement to re-use part of a previous project, anybody should be able to pick up a colleague's work and easily "key into it".
- **Reflective evaluation of practices:** Substantial evidence was found of evolutionary process improvement whereby developers regularly reflect on their own experiences and accordingly refine their practices.

We accept that, on the face of it, most of these practices are not new or original. Rather, for the most part they have long been recognised as standard best practice

and as such are not essentially "agile". Indeed, a criticism that has been made of agile methods is that they can be argued to be "old wine in new bottles" [16]. The counterpoint is that, in practice, very many in-house approaches combine elements of "agile" and "plan-driven", mixing the tried-and-trusted benefits of the old with the more radical and innovative elements of the new.

Regarding the comparability of the two surveys, care must be taken in interpreting the findings because the fact that the Croatian sample contained a greater concentration of small companies and graphic designers may have biased the results somewhat. That said, the findings of the two studies are more alike than different, which suggests that for the most part they can be broadly generalised across similar European nations. The most notable difference between the two samples is that Croatian Web developers seem much less inclined to use explicit, written-down plans, processes and requirements specifications than Irish Web developers. This, we suggest, is a contributory factor to the greater level of difficulty experienced by the Croatian developers as regards the management of changing requirements and the preparation of accurate project estimates. In both of these regards, Irish Web development firms appear to be ahead of their Croatian counterparts in terms of process maturity, so in light to provide answer to RQ2, here is one area where lessons can possibly be learned. First steps have already been taken by introducing the students in Croatia to the state-of-theory in Web/hypermedia methods and current web development practices as well as the differences between Ireland and Croatia.

The limitations of survey research are well known, not least of which being that a survey reflects a situation at a snapshot in time and by the stage the findings are produced that situation may well have changed considerably. Nevertheless, we submit that this paper makes an interesting contribution to the existing body of knowledge in the field, especially because comparatively few empirical surveys of Web-based systems development practices have appeared in recent years. Lessons learnt during analysis of the Irish and Croatian research results enabled us to focus our activities in two areas: firstly, to enhance/renew academic course curricula with contemporary and practical information, and secondly, to explore the issues uncovered by the surveys. Further research is ongoing, involving closer follow-up interviews and case studies that investigate more deeply the use of agile or agile-like methods in Web-based system development.

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