Information Systems Architectures and Systems Integration: an empirical study of French Small to medium Enterprises

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ABSTRACT:
SMEs are a primary driver of economic growth and in the European Union. Yet relatively little is known about how these organizations use information system resources to achieve interoperability and integration. This paper, based on a cross-sectional empirical study of IS architectural integration within 143 small to medium enterprises (SMEs) in France, reports findings on how SME organize and archi- ect to achieve IS integration and/or interoperability. This research provides an empirically derived taxonomy of enterprise architectural variants of the types often described in the literature for large firms. This study finds indications that for SMEs the immediate goal of interoperability prevailed over a fuller and more formal system integration. Comparing the three IT architectures and IS systems integration types, the most common means for approaching any form of integration is via the construction of software bridges and interfaces. The paper makes a contribution to research method by explaining how a European analysis tool, SPAD, helps identify clusters and thus help confirm that SMEs are in different class of organization types with reference to IT architectures and IS integration, and that these firms do things differently than large firms, at least in France.

Keywords: Information Systems Integration, IT architecture, SME (Small to Medium Enterprise).
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Introduction and Problem Statement

Achieving information systems integration, a daunting task for any organization, is especially challenging for small firms. Specific challenges facing SMEs during these projects are related to their small size, centralized management, lack of organizational specialization, intuitive strategic planning, and relatively unsophisticated deployment of information systems. Typical SMEs face difficulties during IT adoption arising from a lack of technical competency and know-how, shortages of qualified human resources, and insufficient support technologies or organizational structures (Ballantine et al., 1998; Duhan et al., 2001; Blili & Raymond, 1993). Small firms have relatively fewer resources to redeploy than in larger organizations while still facing the same competitive challenges and reasons for investing in information technologies and information systems as the large firm. There is evidence that SMEs trying to achieve a measure of integration through the deployment of ERP systems have relatively more problems in gaining sufficient participation from different organizational functions during ERP selection (Laukkanen et al., 2005).

Small to medium enterprise (SMEs) are also major engines of economic growth and employment worldwide (Susman, 2007). They make up 99% – roughly 25 million – of all enterprises in the employ almost 95 million people and account for more than 60% of economic activity worldwide. In Europe, 1.1 million of these firms contribute 40% of the total European economic turnover. In France, the setting from which this study is drawn, SMEs represent more than half of all private employment and more than half of gross national product. SMEs are also understood to be sources of creative energy and innovation providers of novel solutions to practical problems. SMEs face the same competitive and environmental challenges as any other firm, but because they have a proportionately smaller resource base to draw from, it has been suggested that to survive they must be more frugal and creative in the management of organizational resources (Admiraal et al., 2003; Ács et al., 2008; Ács & Szerb, 2009). We maintain that having better empirically derived understanding of how the SME sector uses information systems resources to achieve measures of interoperability is warranted given their sheer number and economic impact. But of equal interest is the way they manage to acquire, husband and deploy these resources for two reasons. First one the one hand, novel models of how they manage the task these resources
were to be discovered others would benefit from this knowledge. Second and on the other hand if finding patterns of problems in this population of organizations later leads to more efficient operations for these firms then society benefits. In either case describing how SMEs approach the problem of information system integration is needed because much of the current literature examines IS integration through the lens of the large-scale enterprise and it is unclear if these finding generalize well to the SME. Although some surveys and comparative literature exists on ERP adoption (Buonanno et al., 2005), SME-specific IS integration surveys are virtually non-existent.

In beginning this research we wanted to know what types of IS architectures (if any) were present in SMEs. To explore this question we set out to determine if and how SMEs dealt with systems integration to achieve systems interoperability and whether the approaches they use correspond to the canonical types discussed in the mainstream literature on enterprise systems integration. This involved examining both the organizational context and the particular tools and technologies used by the SME; but we paid special attention to the technological context in trying to understand the phenomena of interest.

We agree with the claim made by Orlikowski and Iacono that the social sciences, IS included, have privileged the organizational context at the expense of the technological context (Orlikowski & Iacono, 2001). We see much of the mainstream IS literature as focusing on why people develop and use IT in organizational settings. The IS research field has developed sophisticated economic, psychological and sociological instruments and techniques for studying these issues. However in much of this literature the specific technological object of interest is referred to in very general ways. Unfortunately, generalized references to technological concepts deprive us of the ability to describe those objects with and any degree of precision. This may lead to another problem recognized by Orlikowski and Iacono when they called for a reconceptualization of the IT artifact. They observed “that information technology is not a major player on its own playing field [that]…IT artifacts are either absent, black-boxed, abstracted from social life or reduced to surrogate measures.” We see one way to “put the IT back into IT research” is by giving greater clarity of definition about the IT artifact.

We see this research as positioned between Orlikowski and Iacono’s tool view and ensemble view of the IT artifact. This is because the study examines which information technologies are present as backbones of the architecture and also how they are used to further information systems integration. As social scientists we cannot ignore the organizational context, so we describe IS architectures and systems integration in light of organizational settings. Given our world view
regarding the IT artifact, as the starting point we first turn attention the definitions of the artifacts under consideration. The definitions are important for three reasons. First, as Postman (1988) reminds us the study of a discipline is principally the study of the language of the discipline. Because information systems research embraces and arises from several reference disciplines terms are often borrowed from one domain and used in another, but in the process of appropriation they may be used in ways that differ and are not fully aware of the discourse surrounding them in the other domain (Truex & Baskerville, 1998). Establishing a clear definition of the term in question helps determine the precision of the finding. Where events or technologies conspire to create properties that emerge from the confluence of both we need a name for those properties; or put another way by poet Mark VanTilburg, “In naming meaning begins” (VanTilburg, 1973). For Davenport establishing a definition is the first step for being able to manage a process (Davenport, 2005). Davenport’s line of argumentation is that: agreed upon terms lead to agreed upon meanings. These agreements allow for standardized use, and in turn, the identification of metrics, and in developing standard measures that may be used to compare and control process. That is, to manage.

We respected the importance of the challenge that IS researchers reconsider the IT artifact when we developed an exploratory research plan with two primary research questions:

• RQ1: What are the main IS architectures found in SMEs?
• RQ2: What kind of systems integration approaches are present in SMEs?

This paper makes a contribution to theory development via a clarification of the definitional confusion around the term “systems architecture” and in providing an empirically derived taxonomy of IT integration forms. The paper makes a contribution to research method by explaining how a European analysis tool, SPAD, helps identify clusters and thus help confirm that SMEs are in different class of organization types with reference to IT architectures and IS integration, and that these firms do things differently than large firms, at least in France. The paper also contributes to practice by providing a clarification of the rationality guiding each SME type.

The paper proceeds as follows: in section two we situate and discuss the persistent question of IT-organizational integration and prior research on IS architectures (sometimes called enterprise architectures) and the integration of Information Systems. Section three explains the research methodology. Section four presents results including a taxonomy\(^1\) of architectural standards

\(^1\) We remind to the reader, that a taxonomy is an empirically derived classification as compared to a typology that is a theoretical and untested construction BENSAOU B and VENKATRAMAN N (1995) Configurations of interorganizational relationships: A comparison between u.S. And japanese automakers. Management Science 41(9), 1471-1492.
arising from our analysis of a large sample of French SMEs; one that differs from commonly cited typologies in the literature. Section five discusses the findings and draws conclusions for future research.

Prior research

IS architectures and Systems Integration

The notions of information system integration and information system architectures are conceptual siblings. The planned inter-operational integration of systems has been the gold standard for senior and operational managers for years. The goal of creating systems that are truly interoperable, has driven research and practice through generations of conceptual development in information engineering, database research, ERP, EAI, and more recently of service architectures. Yet the goal of enterprise systems integration remains elusive. In the following sub sections we examine the key concepts of IS architectures and Systems Integration in the literature, consider why definitional variation exists and offer a rational for making the definitions clearer and provide the working definitions guiding this research. We first turn attention to the concept of “the architecture”

**IS Architecture:** For both IS management and IS academics the concept of an IS architecture has been a recurrent theme for since the very beginning of the IS discipline (Brancheau & Wetherbe, 1986); (Farrell & Saloner, 1985) and remains a critical concern today (Luckham & Vera, 1995; Medvidovic & Taylor, 2000). Interest in designing and developing stable, scalable, interoperable architectures and infrastructures regularly appears in the Society for Information Management (SIM) annual survey of IT management concerns and continues to appear in the IT literature on Databases, e-commerce, strategic IS Planning and software engineering (Colomb & Orlowska, 1995; Brousseau, 1994) (Gomaa, 1995; Hamilton, 1999; Niederman et al., 1991; Sambamurthy & Zmud, 2000; Sowa & Zachman, 1992; Segars, 1998). The development and deployment of IS architectures also addressed in the literature on managing organizational information systems. (Chalmeta et al., 2001) Much of this literature addresses the properties or attributes of an IS architecture but in general the literature assumes a general agreement or common understanding of the term ‘IS architecture’ and does not discuss the meta level concept itself.
The notion of an ‘architecture’ is therefore problematic in part because it seems to be a usefully ambiguous notion. That is, the notion is often used at a high level of abstraction where anyone can agree that it is a useful concept. But, at lower levels of abstraction, it has many different meanings and realizations. (Peristeras & Tarabanis, 2000).

Corneliussen, describes architecture as being “a plastic concept…A complex metaphorical idea that shapes the categories, discourse and language used”(Corneliussen, 2008). For instance Smolander et al, (2008) “identify multiple metaphors–‘blueprint’, “literature’ “Language” and “Decision” that stakeholders use to understand …software the term software architecture and effectively participate in its use.” (Smolander et al., 2008, p575.) The architecture as blueprint metaphor architecture is seen as the “structure of the system…a plan for some future IT artefact.” In our literature variants of the notion include: architecture, application architecture, Information Architecture (the rationality and design of databases (Finkelstein, 1989; Martin, 1986), Enterprise Architecture (Boh & Yellin, 2006; Zachman, 1997), Software Architecture (Kruchten, 1996; Grünbacher et al.; Grunbacher et al., 2004), IT architecture, and Enterprise IT Architecture. To make matter worse these various terms are often used interchangeably causing greater confusion.

In this paper, as a base definition of architecture we adopt the definition of an architecture provided by the IEEE (Institute of Electrical and Electronics Engineers) standard 1471-2000 that reads:

“the fundamental organization of a system, embodied in its components, their relationships to each other and the environment and the principles governing its design and evolution”.

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2 However there are analogues from other disciplines. To provide better understanding off what the various use off what the term “architecture” are trying to express train we offer this example from urban planning. Plane The urban off general Paris mandated the concept off has city center with which occurred radiating out from the center to does not have point six kilometers out where has boxing ring road would Be constructed. Drank the actual building and placement off the roads, parks, statuary, bridges, tunnels and public places represents the realization off the plane, which edge off race Be accomplished in different ways. Hence the implemented architecture is the existing layout, gold the mapping off the components within the general guidance off the larger “enterprise architecture” which is the plan that itself incorporates has logic for combining future and present activities. In fact in the urban planning domain this is three-level construct in which the highest general level describes the off strategic concept has year urban settlement and the rationalization for the city itself arising within historical geographic, political and economic contexts. The next level has off idealized plane that generalized strategy, the “plane Urban” and the third and lowest level is the actual “off have built” plane gold representation the plane in action, has representation off the roads and other infrastructural elements in place today.
At the level of a broader overarching construct we find notion of an ‘enterprise architecture’ supporting the alignment of IT and business goals. (Lapkin, 2004; Rohloff, 2008; Rohloff, 2005). Our view is consistent with Ross’s notion of the Enterprise Architecture as an organizing logic.

“The enterprise architecture is the organizing logic for business process and IT capabilities reflecting the integration and standardization requirements of the firm’s operating model.” (Ross et al., 2006)

In fact Ross, saying that an enterprise “IT architecture [also]…lacks a universally accepted definition” (Ross, 2003, p. 31), characterizes the concept of an architecture three ways–as Enterprise Architecture, IT Architecture and Enterprise IT architecture. We summarize Ross’s characterizations in table 1 below. The table illustrates that although a suitable comprehensive definition may not be established in the literature there are definitions at different levels of organizational abstraction.

At the level of the technical system Ross and other refer to the “IT Architecture” which covers both technical standards and infrastructure level elements.

“The term IT architecture…the terms architecture and infrastructure are sometimes used interchangeably, with architecture seen as the plan for the next infrastructure. More often, IT architecture refers to a firm’s list of technology standards. But viewing IT architecture only as technology standards does not connect it to business requirements. The enterprise IT architecture concept, though, does place technology standards in the context of business requirements.” (Ross, 2003, p. 32)

Table 1: Ross’ architectural types

<table>
<thead>
<tr>
<th>Type- Ross terminology</th>
<th>Ross/ Ross et al</th>
<th>Our treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Architecture</td>
<td>“…the organizing logic for business process and IT capabilities reflecting the integration and standardization requirements…”</td>
<td>The logic and goals behind the need for information systems.</td>
</tr>
<tr>
<td>IT Architecture</td>
<td>the plan for the next infrastructure referring to sets of standards.</td>
<td>We prefer the term, IS architecture. Sets of tools with the goal of some level of interoperability and/or integration</td>
</tr>
<tr>
<td>Enterprise IT Architecture</td>
<td>The IT architecture connected to business requirements.</td>
<td>Unclear and not commonly used. More recently termed ‘business integration’ but we do not address this issue in this research.</td>
</tr>
</tbody>
</table>
While we concur with the idea that architectures must be contextualized at different levels of organizational abstraction, we find that the Ross’s first definition mixes two different issues. That is, the rationale of the firm itself and secondly the technical aspects of integration and interoperability.

For us, the ‘enterprise architecture’ is the rationale of the firm behind the set of organizational information systems; it is that which makes sense of these systems. Accordingly in our definition and throughout this paper we distinguish between the logic behind (i.e., enterprise architecture) and the operationalization of how information systems components are made to communicate or to connect at a relatively superficial level (i.e., its level of integration or of interoperability).

Ross further identifies a “four stage model of increasing enterprise IT architecture competency”: 1) the application silo, 2) standardized technology, 3) a rationalized data architecture, and 4) modular architecture. For Ross these stages are achieved through a hierarchical evolution wherein companies develop IT architectures dealing with data, infrastructure and applications (Ross, 2003, p.37). To our thinking this viewpoint privileges the role of the IT architecture rather than the IS integration process itself.

Having examined the definition of architecture we now turn to the second and closely related concept, that of IS Integration.

**IS Integration:** The origins of the term systems integration, as we are reminded by Beniger (1986) and Ross (2003) is technical and closely associated with the application implementation level of abstraction. The integrated information system is an ideal or kind of “holy grail” sought by both researchers and vendors alike (Besson & Rowe, 2001; Beniger, 1986). We find many different types of “integration” illustrated in the literature: database, taxonomy, meta types, process integration, application integration, or simple API connectors. We see these characterizations of integration as falling into two generalized classes: first, those providing interconnectivity between the individual components of hardware infrastructures, and; second, those providing software interoperability of applications (packages), of processes (ERP) or of data (databases) or combinations of these three elements. (Boh & Yellin, 2006; Boh et al., 2003).
There also exist different scopes of integration; those within or between the domains of the work system, department, function, firm, supply chain and industry. These are sometimes referred to as inter and intra organizational systems. At the **datalogical** level, database integration, a “natural progression in the development of database systems” provides the means to both rationalize the sharing and access to data (Cheney & Kasper, 1993, p.28). At the **application and process levels** integration is sometimes equated with an ERP implementation even when the ERP systems are deployed in ways that only allow for integration across limited domains in a firm. Such implementations are, in effect, treating the ERP as just another application. In these instances rather than providing greater organizational systems integration the ERP simply creates stovepipes of localized integration and may further exacerbate other islands of automation (Huin, 2004). Worse yet, highly customized ERP implementation may make further integration of data and processes extremely difficult and unlikely (Truex, 2001). In these instances overall integration is stymied, and the benefits or ‘standard’ solutions backfire.

Drawing from the world of practice, Markus (2000b, p.7) provides a description of three “broad approaches to systems integration”. (c.f., Table 2) After dismissing application-interface integration as insignificant because it only connects superficially at a high level of abstraction leaving processes and data alone, Markus describes: (1) data warehousing (or Data extraction technology), (2) enterprise systems (ERP technology) and (3) re-architected systems (EAI/Middleware technologies) as routes to intra-organizational integration. Markus (id.) contends that “…data warehousing and enterprise systems are more mature than the re-architected solutions”.

The typologies and examples as provided by both Ross et al, Markus and others, and as discussed above, were derived from very large-scale organizations; and both Markus and Ross dismiss the building of software interfaces as a kind of *bona fide* integration. Our own research examines the behaviors of much smaller-sized organization. And the research is primarily concerned with how SMEs, *in practice*, actually do achieve varying degrees of interoperability or even of integration. So as we began our analysis of data drawn from the domain of the SME we wondered if the characterizations Ross and Markus derive from the domain of the large organizations would
prove to hold true in the case of SMEs in France. In our data we found that many actually used APIs and software bridges as whole or partial solutions for achieving information system interoperability. Accordingly we find it necessary to reintroduce the application interface-level approach (called Interface or software bridges) in our explication of the Markus-identified integration approaches in Table 2.

In table 2 we compare integration approaches using six different criteria for comparison. Those criteria include: 1) the databases e.g., are they distributed, one logical data model or several relatively independent models (Giachetti, 2004; Giachetti et al., 2003); 2) the logical view of the architecture, (Kruchten, 1996); 3) integration practices, i.e., what you do with the technology 4) integration impacts (Markus, 2000; Rowe et al., 2005), 5) major architectural feature, the primary focus of the integration practice, and finally the 6) major integration object, the focal object of the integration approach (Peristeras & Tarabanis, 2000).

---insert Table 2 about here---
Markus’ Terms

Architectural dimensions

<table>
<thead>
<tr>
<th></th>
<th>1. Data warehousing</th>
<th>2. Enterprise systems (ERP)</th>
<th>3. Re-architected systems (EAI)</th>
<th>4. Interface or software bridges (APIs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Databases</strong></td>
<td>Several DBs with extraction to a data warehouse for processing and analysis</td>
<td>Several DBs but only one logical DB</td>
<td>Several DBs but only one logical DB</td>
<td>Several DBs</td>
</tr>
<tr>
<td><strong>Logical view of the Architecture</strong></td>
<td>Hierarchical: Tree structure</td>
<td>Modular</td>
<td>Modular and tree structure</td>
<td>Opportunistic, Heterogeneous, patchwork, bricolage</td>
</tr>
<tr>
<td><strong>Major integration practices</strong></td>
<td>Extraction and pertinent processing of data</td>
<td>Re-engineering of processes</td>
<td>Interconnection of application’s DBs</td>
<td>Interconnection of few applications and/or DBs</td>
</tr>
<tr>
<td><strong>Major integration impact</strong></td>
<td>Structuring of data and updating of processing</td>
<td>Real time, unique reference and cross-functionality</td>
<td>Increase the scope of extant/legacy systems w/o changing logical data models</td>
<td>Degrees of interoperability</td>
</tr>
<tr>
<td><strong>Major architectural feature</strong></td>
<td>Data extraction process</td>
<td>Single Logical Database; Modular architecture</td>
<td>Middleware</td>
<td>Application Connectors</td>
</tr>
<tr>
<td><strong>Major integration object</strong></td>
<td>Data</td>
<td>Database and Process</td>
<td>Application</td>
<td>Application</td>
</tr>
</tbody>
</table>

Table 2. Characterization of approaches to IS integration or interoperability

These four types, shown in table 2, describe systems solutions that can be either (1) *complimentary*, as in the case of the conjunction of ERP and Data warehouse or, (2) *substitutable*, wherein types may be used in combination at the operational level or may be entirely replaced as in instances were an ERP replaces a set of prior systems. Functionality may differ but all changes to the systems are made in response to real-world organizational requirements. Thus we refer to these four approaches as: 1) Data warehousing, 2) Enterprise Systems (ERP), 3) EAI re-architected systems and 4) Interface software (API). Each of these has “pros and cons” arising from various organizational, competitive and environmental factors (Markus, 2000). We note, for instance, that

- Data warehousing achieves data integration without changes in source systems or business process. Data warehousing does not, therefore, support process integration.
- Conversely, ERP systems achieve excellent internal data and process integration when all legacy systems are replaced. But ERP systems demand a single common data model. Thus ERP systems limit the opportunities to incorporate external data sources and do not
readily allow integrated reporting and analysis environments requiring both internal and external data. ERP solutions also often require extensive organizational change and dislocations. “The problem with this thinking is that it assumes that the ERP software provides an acceptable level of business fit when it is first implemented.” (Light et al., 2001)

• Enterprise Applications Integration (EAI), achieves internal data integration and can support process integration without replacement of legacy systems (Irani et al, 2003). This allows a firm to retain legacy systems for some operations and keep extant production databases. However, EAI requires modification of source systems. So like ERP systems, EAI also encourages use of “best-of-breed” applications from multiple vendors. Yet EAI leaves the organization with vestiges of its original and familiar systems. Because it is new and untried, difficult and expensive, and so SMEs are still suspicious about the maturity, the future and applicability of this technology.

• APIs allow limited degrees of interoperability without requiring any formal architectural planning. In this approach the individual application is king and the pragmatic need to connect at a superficial level requires the development and maintenance of software bridges linking application to application. Their development may be haphazard and may, over time, become a bricolage of programming. If the organization and its systems grow substantially the complexity of maintaining these individual software APIs may overwhelm or force a move to other more formal or systematic integration approaches. But it is also true that this approach may well serve those small organizations having few applications for a very long time.

How standard are these approaches?
The typologies as discussed above provide an attractive and somewhat intuitive and clear description of how firms might go about architecting and integrating information systems; but the real world is messy. The IT manager is always facing the pragmatics of daily operations while having to rationalize the systems architecture. In practice one rarely sees IT architectures based on only one type of IS integration approach; there tend to be many mixed and partial systems integration implementations. For instance among firms deploying ERP systems very few adopt all the available process modules, opting not to be fully committed to the integration and standardization options required by the ERP (Themistocleous et al., 2002; Rowe et al, 2005). Or,
when firms merge, bringing legacy systems and databases from each firm, it is often necessary to integrate data from multiple sources. At the strategic and practical level, combining data warehousing *in addition* to ERP systems may be required (Holland and Light, 2001). The combination may forestall a situation wherein one of the merged firms has to abandon its investment before integrating its systems. This suggests that the requirement that systems be up and running is an overarching concern. As a consequence their linkages are a prime concern whereas the formality of the rationality governing the operations and interoperability of these systems is of secondary concern. Because of this we were also very curious to see if in our data we might discover clear delineations in architectural and integration approaches.

We next turn our attention to the research design, data collection and analysis of the findings.

**Research Method and Research Model**

Much of the empirically based literature on IS architectures and systems integration is based on case studies (Markus, 2000a, Ross, 2006, Avital & Vandenbosch, 2000, Truex, 2001, Irani et al., 2003; Bidan & Rowe, 2004) as compared to survey-based research; a notable exception being Tractinsky and Jarvenpaa (Tractinsky & Jarvenpaa, 1995). Our research described in this paper arises from larger project developed to better know the kinds of IS architectures in place in various sized French businesses. Previous publications from this research project have addressed the use of ERP in the firms (citations withheld during review). This paper explicitly addresses the SME portion of the larger data set. At the outset of this research program we chose a mixed methods research design in which we conducted field studies, interviews and collected survey data. Part of the research involved an exploratory questionnaire from which we intended to conduct a kind of cluster analysis to identify similar sets of organizations from which we could select exemplars with which we might perform in-depth case studies (citations withheld during review). This present paper extracts from the exploratory questionnaire. We view this research as exploratory because we do not test propositions drawn from a body of well-developed theory. As illustrated in the literature review above the field is adjusting to the constantly evolving techniques and technologies. In settings with well-established constructs and relative stability it is possible to theorize. However, our field has yet to develop a theory about the IS architectural artifact. So at one level we see this research as contributing to the description of the artifacts and
to further the development of taxonomies by which we can establish standardized terminology and later theory of those artifacts.

In this paper the descriptions of the IS architectures and systems integration are derived through statistical analysis rather than being derived from a particular theory *ex ante* to the research (c.f., footnote 1). Why? Because we are looking for commonalities between organizations in various demographic clusters and we cannot preclude any particular commonality *a priori* to the analysis. For example, do any of the integration patterns resemble the approaches described in table 2? We simply identified the types that surfaced from the cluster analysis and then compared those to these approaches derived form the literature. This research follows the well-established French school of multivariate analysis (Lebart et al., 1984a) more fully described below. We ask the reader who might be unfamiliar with these techniques and tools to hold any preconceptions of the data analysis in suspended animation until the end of the following section.

**Data Collection, Pre-testing and Sample Selection**

**Data collection**

Data was gathered during the spring of 2002. One author had developed a firm contact list of more than 600 French firms during his supervision of professional student internship placements. Starting with this database, he selected a convenience sample of the 223 firms whom he knew to be concerned about their information system issues. He made telephone contact with key IS decision-makers asking them if they would agree to answer a short questionnaire about the firm’s IS architecture, systems integration and firm demographics. In each instance his contact was the manager most knowledgeable or principally responsible for the firm’s system integration issues. Most of the time the respondents turned out to be the CIO.

The initial questionnaire was developed in following an extensive literature review and discussion with team members and other researchers examining these issues in larger firms in France and the United States. The survey instrument was pre-tested with 13 integration

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3 We know this to be a large share of the firms established in the two regions in France from which the sample is drawn. However we do not claim that is representative sample from which we should generalize to all firms. (Lee and Baskerville (2003, 2007)
practitioners, project managers and CIOs. The survey pre-tests helped clarify terminology and cut the length of the questionnaire. In the pretest phase we found that the data warehouse concept required clarification and explication. For many SME managers it was simply not relevant or applicable. So, when it was later determined that none of our SME survey set deployed data warehousing, this item was removed.

In our pre-contact phase, when we invited firms to participate, 223 firms had agreed to participate so two hundred twenty three (223) surveys were sent out. Out of those sent 156 replied, a remarkable 64% yield. We followed up with telephone questions when surveys were incomplete. But even with our telephone follow-ups 61 firms never completed the instrument and we had to eliminate another 13 survey responses considered to be inconsistent or illegible. So in the end, we had one hundred forty three (143) useable surveys, still a 64% yield. By comparison an earlier attempt to survey SMEs using ‘cold call’ mailed instruments to SMEs in Paris netted a paltry a 15% response rate. In this research the data collection was highly interactive and we believe that our ‘high touch’ process of data collection explains the high response rate and the high quality of the data obtained. The researcher collecting the data remained in contact and engaged through out the process, talking with many of the respondents about their understanding of the questions. During this contact he found that 23 SME representatives had some terminological questions requiring clarification before replying. Those questions dealt with the meaning of the terms “satisfactory integration” (Singletary, 2002) and with the nature and classification of integration tools (Markus, 2000).

**Measures**

The questionnaire had two main parts. The first part described the organizational context and demographic characteristics including age and size of firm. Part Two addressed the degree of IT architectural integration by including questions asking the degree and maturity of system integration (Markus, 2000; Ross, 2003). The questionnaire included 15 items covering contextual issues and IS architectures and IS integration. The construct, the possible item values and the underlying core notions for the question are described in Table 3 below.

<table>
<thead>
<tr>
<th><strong>A. Contextual Items</strong></th>
<th><strong>Possible Item Values</strong></th>
<th><strong>Core notion and reference authors</strong></th>
</tr>
</thead>
</table>

15
<table>
<thead>
<tr>
<th></th>
<th>What is the number of employees in your firm?</th>
<th>30-100 or 101-500 or &gt; 500</th>
<th>Pragmatic classification based on ERP vendor and French taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>What is the main activity in your firm?</td>
<td>Agriculture or Manufacturing or Services</td>
<td>A classical distinction still appropriate</td>
</tr>
<tr>
<td>3</td>
<td>What is your main organizational type?</td>
<td>Functional-oriented or Project-oriented or others</td>
<td>Blili and Raymond (1993) SME and IT Systems. Applies not only in most developing countries, China and India, but also in many Regions of the western economy.</td>
</tr>
<tr>
<td>4</td>
<td>What is the age of your firm?</td>
<td>&lt; 5 or 5 to 10 or &gt;10 years</td>
<td>Blili and Raymond (1993) as above</td>
</tr>
</tbody>
</table>

**B. Technological Items**

<table>
<thead>
<tr>
<th></th>
<th>How many vendor ERP packages have you implemented in your firm?</th>
<th>0 or 1 or &gt;1</th>
<th>Packaged software (Light, 2005; Xu and Brinkemper, 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>How many ERP modules of the same package have you implemented in your organization?</td>
<td>1-3 or 4-8 or &gt;8</td>
<td>Modules (Parnas, 1972); Markus 2001</td>
</tr>
<tr>
<td>6</td>
<td>Have you implemented any “support function” type ERP module?</td>
<td>Yes or No or No answer</td>
<td>Porter (1985) core vs. support function; El Amrani et al (2005) Coremodule vs support module</td>
</tr>
<tr>
<td>7</td>
<td>Have you implemented any “core function” type ERP module?</td>
<td>Yes or No or No answer</td>
<td>Same as above</td>
</tr>
<tr>
<td>8</td>
<td>How many legacy systems do you have in your organization?</td>
<td>1-3 or 4-8 or &gt;8</td>
<td>Markus and Tannis (2000). Notion of legacy systems as ‘spaghetti’ confounding later development.</td>
</tr>
<tr>
<td>9</td>
<td>Do you have any non ERP support applications programs in your organization?</td>
<td>Yes or No or No answer</td>
<td>Porter (1985) core vs. support function; El Amrani et al (2005) Coremodule vs support module</td>
</tr>
<tr>
<td>10</td>
<td>Do you have any non ERP core applications program in your organization?</td>
<td>Yes or No or No answer</td>
<td>Same as #10 above</td>
</tr>
<tr>
<td>11</td>
<td>Do you have a common logical databases for MIS?</td>
<td>Yes or No or No answer</td>
<td>Themisoclous, Irani and O’keefe (2002)</td>
</tr>
<tr>
<td>12</td>
<td>Do you have a common IS nomenclature for the firm? Data structure</td>
<td>Yes or No or No answer</td>
<td>Data structure ECIS (Golding et al., 2008; Goldkuhl, 1984)</td>
</tr>
<tr>
<td>13</td>
<td>Do you use an EAI platform or middleware for MIS?</td>
<td>Yes or No or No answer</td>
<td>Themisoclous, Irani and O’keefe (2002); (Markus, 2001)</td>
</tr>
</tbody>
</table>
For you are your information systems satisfactorily integrated?

<table>
<thead>
<tr>
<th>Yes or No or No answer</th>
<th>Themisoclous, Irani and O’keefe (2002)</th>
</tr>
</thead>
</table>

Table 3. Research instrument: constructs, possible item values and core notions

**Data Analysis: Statistical tool and tests**

**Cluster Analysis:**

The analysis tool we use, *SPAD.N version 3.21*, may be unfamiliar to non-Francophone researchers. The tool is commonly used, and is well accepted, in France both by researchers and practitioners. The main reasons for using SPAD.N is that 1) it integrates methods for analyzing multiple correspondence in nominal data; 2) its power in analyzing the automatic ranking classification; 3) for its descriptive power in identifying clusters and describing them by characteristic modality, and; 4) for the relevance of its aggregated criteria of the primary measure, namely the *Value Test (V.T.)*. SPAD.N and its use has already been introduced in the English language IS literature (Rowe & Struck, 1999).

Analysis: We first performed a cluster analysis, to discover factors differentiating the firms in our convenience sample. In rough terms this is a two steps process. Step 1 involves the construction of the main clusters derived iteratively in the statistical tool SPAD (Lebart et al., 1984). The second step is to describe each cluster. Those descriptions arise from the various value test and other statistics as described below.

**Cluster formation:** There are several methods for forming clusters. (Everitt, 1993, Hair et al., 1998, Sharma, 1996). In this study, we essentially used a hierarchical agglomerate method to define initial cluster. In contrast, the nonhierarchical procedure does not involve the construction of a treelike structure, where the results at an earlier stage are always nested within the results of a later stage (Gerdin, 2005). Instead, objects may be reassigned if they are closer to another cluster than the one originally assigned. In this study, we examine the results from the hierarchical clustering procedure and make adjustments as part of the iterative analysis to establish the number of clusters.

“*A critical issue in cluster analysis is the determination of the appropriate number of clusters. Unfortunately, no generally accepted criterion exists. Researchers are therefore reduced to using existing theory to identify a natural number of clusters that are interpretable in terms of the research question. However, as a complement, more formal “rules of thumb” can be used. One such method is*
to examine how the distance between objects within clusters changes … as the number of clusters decreases. The idea is to identify the points where within-cluster distance makes a sudden jump.” (Gerdin, 2005)

In this analysis we choose three clusters because they provide the best partitioning and representation of intra-cluster relevance and inter-cluster distance (See Table 5 below).

SPAD.N’s cluster analysis approach identifies and systematically sorts, among the variables included in the model, those (discrete or continuous) that are statistically significantly related to a specific discrete variable. The test compares various proportions using, on the one hand chi-square for discrete variables and, on the other hand a statistic related to the t-test for continuous variables. The computed statistics are converted into a probability level, allowing for a simultaneous sorting of both types of variables. In order to assess the differences between percentages or average means, SPAD.3.21 performs different statistical tests (hypergeometrical law for proportions and corrected t-tests for average means) that it expresses as the standard deviation of a distribution. The value test, VT, equals the standard deviation (for VT >2, at the 5% error threshold). Typically it can be used for answering a complex question such as "Is the proportion of enterprise architecture which are categorized by some integration greater when these EAs use ERP than when they use a other technology ?" (Rowe & Struck, 1999). To learn more about the tool and these techniques refer to Lamarche (Lamarche et al., 2003).

Cluster separation and description: The level of difference between the clusters is given as a set of researcher-selected variables. It is a type of multi-variate analysis. The analyst examines the relative strength of individual variable or subsets of variables (including outlier variables) that the tool has characterized by its various measures of cluster closeness/relatedness. In SPAD.N these measures are characterized as Value Tests. The next step is to interpret these clusters and relate them back to our empirical analysis template drawn from the literature.

Dendograms: A dendogram is a visual representation of the clusters. It shows the entire sample organized by the relative nearness factors computed by the clustering tool. We used a hierarchical clustering procedure as represented in the dendogram (figure 1).

“Within the hierarchical cluster procedure, there are several ways of forming clusters (see Sharma (1996) for an overview of widely used clustering algorithms). Ward's optimizing algorithm, combined with squared Euclidean distance as the measure of similarity, was chosen on the basis that it has been widely used within the social
is sciences (Everitt, 1993). This method maximizes within-clusters homogeneity; i.e., it minimizes the within-group sum of squares (Sharma, 1996).” (Gerdin, 2005)

Sample description

The study initially targeted the midsize market segment as defined by the ERP vendor’s market criteria. It quickly became apparent that the primary criterion in the purchase decision for the SME market segment, is “the fit with current business processes” (Van Everdingen et al., 2000). Small to Medium Enterprises (SMEs) are, like their larger-firm brethren, courted by a host of ERP vendors and system integrators. From the ERP vendor’s point of view their midsize market is defined as comprising firms employing from 30 to 3000 employees. (c.f., SAP annual report for (2006) or Gartner market reports, (Scavo, 2007)). For instance SAP itself describes its product Business One as being for firms employing from 30-300 and R/3 as being for larger firms. Smaller firms are ceded to other vendors such as SAGE Software or Intentia. But SAP clearly acknowledges that the midsize market is an important and growing part of their portfolio. In fact, these market segments account for approximately 65% of SAP’s total customer base, and are an important part of our plan for ambitious revenue growth through 2010.

4 Including SAP (R/3, Business One), Oracle Application, Microsoft (Axapta/Dynamics AX), Sage (X3), Lawson-Intentia (Movex), etc. because SMEs even facing the same problems tend to demand quicker results at lower cost than larger firms.
In Table 4 we see that 98% of firms in our sample belong to the “midsize” segment, that is 30-3000 employees. At the tails of the distribution we note that only 2% of firms in our sample are smaller than 30 employees and 16% employ more than 500 people. Because of the size distribution of our sample respondents, and since in France the medium size firm employs between 100-500 employees, small firms employ from 10-100 and so called micro-firms employ fewer than 10, we have adopted a French-sized classification scheme. As to firm size our sample mean is 244.5 with a rather large standard deviation of 347.5. This deviation occurs because a few of the sampled firms were relatively large having between 2,500-3,000 employees. (c.f. Table 4 below)

<table>
<thead>
<tr>
<th>Size</th>
<th>10 to 30</th>
<th>31 to 100</th>
<th>101 to 250</th>
<th>251 to 500</th>
<th>501 to 3000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>3</td>
<td>72</td>
<td>16</td>
<td>29</td>
<td>23</td>
<td>143</td>
</tr>
<tr>
<td>%</td>
<td>2</td>
<td>50.5</td>
<td>11.1</td>
<td>20.2</td>
<td>16.2</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4. Sample distribution

**Partitioning the sample**

As described earlier in the discussion of the clustering technique we used in SPAD.N, we will explain the relevance of an n-wise partitioning of the sample into 2, 3 and 5 categories. We examined the before and after comparisons of inter-class inertia/ total inertia ratios. We retained only the most stable – i.e., those having the smallest in the ratio between iterations consolidation – and the most empirically relevant partitioning. We gained precision and achieved stability after two iterations when the change in the inter-class inertia was almost null (0%) for t. For categories 3, 5 and 7, the consolidation stopped after three iterations when stability was reached. Table 5 gives the main characteristics of the various partitioning and shows the changes in the inertia ratios after each iteration (c.f. Table 5).

<table>
<thead>
<tr>
<th>Best partition combinations in n categories by the change of relative inertia (n = 2 by10)</th>
<th>Number of firms in each category (Total=143)</th>
<th>Inter class inertia / total inertia ratio. Before the consolidation of the partition</th>
<th>Inter class inertia / total inertia ratio. After the consolidation of the partition</th>
<th>Change in inertia ratio (After/Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>C1 = 61 / C2 = 82</td>
<td>0.2648</td>
<td>0.2648</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>61/29/53</td>
<td>0.3485</td>
<td>0.3513</td>
<td>1.0080</td>
</tr>
<tr>
<td>5</td>
<td>61/29/10/11/32</td>
<td>0.4595</td>
<td>0.4668</td>
<td>1.0158</td>
</tr>
</tbody>
</table>
Normally we would stop after the first iteration achieving stability at two clusters – the first with firms having an ERP system and the second as firms without ERP systems. Accordingly, we determined that two clusters were descriptive enough of the integration complexity. So we chose to continue the process and found that with additional iterations we retained nearly the same precision but acquired much greater operational relevance. Although we have reported the fuller results in Table 5 to be consistent and clear we provide a description of the 1st two category partitioning representing respectively 61 and 82 firms. As described earlier, this partitioning shows clearly that IT architecture first differs by the federated versus the integrated archetypal distinction. It then is partitioned by ERP or not ERP, which logically explains the uniqueness of the database.

The Applications Silos type (N=61) displays the following very significant characteristics:

- No ERP (VT = 13.5)
- No common database (VT = 13.5)
- More than 8 specific applications (VT = 4.5)

While the integration type (N=82) also displays the following characteristics:

- One ERP (VT = 14.6);
- Having a common database (VT = 4.3)
- Having between 4 and 8 modules deployed (VT = 6.2).

The “Applications Silos” category (representing 61 firms or roughly 43% of the population) is reasonably homogeneous. The “integration” category, however, can be further fragmented, which is suggested by the partitioning in 3, then 5 categories. The 7 category partitioning shown in table 4, simultaneously fragments the two archetypes of the very first partitioning and is overkill. We found the partitioning into three categories to be more satisfying in terms of change of inertia ratio, and more interesting than the mere distinction between the two archetypes. We will therefore focus on this taxonomy in the following description and analysis.
RESULTS Discussion

A taxonomy of three IS Architecture Types

In this partitioning we have therefore identified three categories or classes, which we call “Applications Silos”, “Partially Standardized Technology” and “Mixed Technology”. We will describe them using only variables for which the value test is greater than 2 (i.e. less than 5% threshold error) and can therefore be considered or statistically significant. Variables always appear by decreasing order of characterization of a category.

First category: Applications Silos

We call this category “Applications Silos”, because our cases show that, most of the time, there are not clear and formalized enterprise architecture policies in the firms falling in this category. However, there is a trend toward a vision of the MIS that calls for some understanding of its enterprise architecture. Even in this category it is becoming quite rare that firms use applications in completely closed silos. However, the logic of the Applications Silos IT architecture is not that of integration in the pure sense, as we shall see below. In table 5 and the following tables, “SA” refers to Specific Applications, or as they are alternatively called in the literature, autonomous applications.

The table structure and presentation we use in this paper, while common in French technical literature, is less common in English literature and requires a bit of orientation. The first column gives all discernable characteristics that were found statistically significant at the .05 level. Column 2 gives the actual Value Test values. Columns 3 and 4 offer different views of the data.

As an example of one such view, row 6 describes those firms without a common enterprise data model. Row 6/ Column 3, Attribute/category, shows that 100% of the 61 Applications Silos firms were did not have common databases. Row 6/ Column 4 shows that 100% of the firms without common databases comprise 86.71% of the total sample of 143 firms. In other words, Column 3 describes the specific attributes of the firms in this category.
### Category 1: Applications Silos

<table>
<thead>
<tr>
<th>Attributes found significant</th>
<th>Value Test (&gt; 2 is significant at the .005 level)</th>
<th>Attribute/Category (% of the category n with this characteristic)</th>
<th>Total sample (% of the total with this characteristic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ERP</td>
<td>13,5</td>
<td>100</td>
<td>42,6</td>
</tr>
<tr>
<td>Support Specific Applications</td>
<td>8,5</td>
<td>88,5</td>
<td>48,2</td>
</tr>
<tr>
<td>Core Specific Application</td>
<td>8,2</td>
<td>88,5</td>
<td>49,6</td>
</tr>
<tr>
<td>&gt; 8 Specific Applications</td>
<td>4,5</td>
<td>39,3</td>
<td>21</td>
</tr>
<tr>
<td>Without a common DB</td>
<td>4,3</td>
<td>100</td>
<td>86,7</td>
</tr>
<tr>
<td>&lt; 100 employees</td>
<td>2,5</td>
<td>65,6</td>
<td>52,4</td>
</tr>
</tbody>
</table>

**Table 6: Applications Silos**

Continuing with our interpretation of Table 6, the Value tests indicate that the Applications Silos category firms are strongly characterized by the lack of ERP systems, and therefore have a large number of autonomous specific applications, (SA) both for operation and support functions. This category tends does not utilize a common logical database and is made up of rather smaller firms of fewer than 100 employees. The architecture looks like a set of heterogeneous applications with few interfaces, and is a non-modular, tree-type, hierarchical architecture. These firms have specific applications without ERP modules in both core activities and support activities (cf. Figure 2).

![Figure 2. Applications Silos](image)
Second category: Partially Standardized Technology

This Partially Standardized Technology category (c.f., Table 7) is characterized by the limited coverage of the ERP (in terms of the number of modules installed). 77% of the firms in this category have from one to 3 modules deployed and one to 3 specific applications. However, 100% of the firms of this class have a unique ERP, 90% for at least one module for its support activities and 77% for its core activities. This category is best characterized by Partially Standardized Technology with 83% reporting having no EAI platform but having no common database. These firms are of rather modest size with 90% having fewer than 100 employees. They are also young firms, 80% of them are less than 5 years old. Their CEO is heavily involved as he or she led the project and responded to the questionnaire. And we can represent this type of MIS IT architecture of this category in the following figure 3.

<table>
<thead>
<tr>
<th>Category 2: Partially Standardized Technology</th>
<th></th>
<th></th>
<th>N2=30 or 21% of 143</th>
</tr>
</thead>
<tbody>
<tr>
<td>Col. 1</td>
<td>Col 2</td>
<td>Col. 3</td>
<td>Total sample</td>
</tr>
<tr>
<td>Attributes found significant</td>
<td>Value Test</td>
<td>Attribute/Category</td>
<td>(% of the total with this characteristic)</td>
</tr>
<tr>
<td>(&lt; 2 is significant at the .005 level)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 3 ERP modules</td>
<td>8,5</td>
<td>76,7</td>
<td>14,5</td>
</tr>
<tr>
<td>A unique ERP</td>
<td>6,5</td>
<td>100</td>
<td>51</td>
</tr>
<tr>
<td>1 to 3 Specific Application</td>
<td>6,4</td>
<td>86,7</td>
<td>35</td>
</tr>
<tr>
<td>Support ERP module</td>
<td>4,8</td>
<td>90</td>
<td>51</td>
</tr>
<tr>
<td>&lt; 100 employees</td>
<td>4,7</td>
<td>90</td>
<td>52,4</td>
</tr>
<tr>
<td>No support Specific Application</td>
<td>4,3</td>
<td>86,7</td>
<td>51,7</td>
</tr>
<tr>
<td>No EAI</td>
<td>4,1</td>
<td>83,3</td>
<td>49,6</td>
</tr>
</tbody>
</table>
Core ERP module &n 3,2 & 76,7 & 49,6
No core Specific Application 3,1 & 76,7 & 50,3
< 5 years old 2,9 & 80 & 55,2
CEO responding 2,8 & 50 & 27,3

Table 7: Partially Standardized Technology

In this category, (cf. Table 8) we see that 29% of the firms do have common databases. Most (83%) have one ERP system. And a few (17%) have more than one. Firms in this category have at least a core activity module (92%), and a support activity module (88%). Many of these firms have from 4 to 8 ERP modules in place (62%) with more than a third having (35%) having 8 or more ERP modules. In transitioning to ERP most firms appear to have abandoned autonomous specific applications in favor of the ERP system’s core operations (81%) and support activities (79%). They often have an EAI platform (65%) as well. Nearly one-third of these firms are among the largest firms of our total sample. This category also represents 29% of the firms having a common database. Because they have generally an ERP and an EAI, and a common
database they represent the closest match to Markus’ broad category of the hybrid firm (Markus, 2000). We represent this category in Figure 4.

<table>
<thead>
<tr>
<th>Category 3: Mixed Technology</th>
<th>N3 = 52 or 36.3% of 143</th>
</tr>
</thead>
<tbody>
<tr>
<td>Col. 1</td>
<td>Col. 2</td>
</tr>
<tr>
<td>Attributes found significant</td>
<td>Value Test</td>
</tr>
<tr>
<td>(&gt; 2 is significant at the .005 level)</td>
<td>(% of the category n with this characteristic)</td>
</tr>
<tr>
<td>Core ERP module</td>
<td>8</td>
</tr>
<tr>
<td>4 to 8 ERP modules</td>
<td>7</td>
</tr>
<tr>
<td>Support ERP module</td>
<td>6.9</td>
</tr>
<tr>
<td>A unique ERP</td>
<td>5.7</td>
</tr>
<tr>
<td>&gt; 8 ERP modules</td>
<td>5.5</td>
</tr>
<tr>
<td>No core Specific Application</td>
<td>5.5</td>
</tr>
<tr>
<td>No support Specific Application</td>
<td>4.8</td>
</tr>
<tr>
<td>4 to 8 Specific Application</td>
<td>4.4</td>
</tr>
<tr>
<td>&gt; 501 employees</td>
<td>4.3</td>
</tr>
<tr>
<td>Common Enterprise DB</td>
<td>3.8</td>
</tr>
<tr>
<td>Several ERP</td>
<td>3.81</td>
</tr>
<tr>
<td>101 to 500 employees</td>
<td>3.4</td>
</tr>
<tr>
<td>EAI Platform</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Table 8: Mixed Technology

Figure 4. Mixed Technology
Findings, Discussion and Conclusions

We present and discuss the findings below.

<table>
<thead>
<tr>
<th></th>
<th>Application Silos</th>
<th>Partially Standardized Technology</th>
<th>Mixed Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Databases</strong></td>
<td>Several heterogeneous</td>
<td>One principal</td>
<td>Multiple databases; database interoperability via middleware data conversion</td>
</tr>
<tr>
<td><strong>Major de facto standard</strong></td>
<td>None: Opportunistic, Heterogeneous, patchwork, bricolage</td>
<td>Via the ERP</td>
<td>ERP</td>
</tr>
<tr>
<td><strong>Major integration tools</strong></td>
<td>Software bridges</td>
<td>Erp &amp; Software bridges</td>
<td>ERP &amp; EAI</td>
</tr>
<tr>
<td><strong>Major integration focus/scope</strong></td>
<td>Within functions</td>
<td>Intra firm</td>
<td>Intra firm and limited inter firm</td>
</tr>
</tbody>
</table>

Table 9. Categories of SMEs IT architecture

1. Interpretation of the Three Clusters

The first form, Applications Silos, is characterized by a) having multiple unrelated databases, that are not united by a common data model, b) integration is effectively the interoperability arising from the building of software bridges and interfaces (APIs), and c) likewise, the tools enabling any interconnection are these software bridges.

We see two ways to interpret why firms exhibit this type of architecture. The first, suggested directly by the data, is that these firms are not particularly young; that is, the age of the firm is not a discriminating factor. Their extant systems were started well before ERP alternatives for SMEs became available, and evolved over time. When the ERP alternative was made available, SME managers faced the decision of abandoning workable interoperable systems and having to allocate substantial new resources for an enterprise solution that they also understood to carry substantial risk of failure. The second interpretation comes from in-depth cases drawn from this sample and investigated and previously described (citation withheld during review). Strategically firms did not want to integrate different business functions because they feared such integration would risk disclosure of critical and survival threatening confidential information. To them, total integration simply did not make sense.
The second form, Partially Standardized Technology wherein integration, is characterized by: a) having some limited ERP implementation (single vendor only) which imposed *de facto* standards; b) also having software bridges in addition to the ERP system, and; c) achieving integration via the ERP and any additional software bridges. From the data we know these firms are both young and relatively small. Unlike the case of the Applications Silos, we attribute their acquisition of ERP systems to two things. The first is that, for owners/managers, the information systems are neither a core competency nor their primary focus, so achieving integration as simply as possible is more appealing than building in house systems, and; that the ERP opportunities were presented at the right time. As noted above 80% of these firms used ERP with 3 or fewer modules. They commonly elected to exclude databases for R&D, and customer identity data.

The third form, Mixed Technology, is the most advanced with regard to IS architectural and systems integration because this organization type mixes applications middleware and ERP systems. They are characterized by: a) having common database models, b) widespread use of an ERP system, with integration standards arising from the greater adoption of the ERP modules, and; c) by combining ERP and EAI technologies (middleware). This set of SMEs tends to be the larger firms in our sample. From our previous casework we discovered the primary IS issues these firms expressed were those dealing with operational efficiency and interoperability with certain privileged customers (citation removed during review). Because these firms wanted interoperability, flexibility and cost efficiencies they chose to standardize around the ERP/EAI. They clearly understood the benefit of aligning the IT implementation with firm growth strategies.

Each of these types has an internal logic. That logic for the first type is heavily influenced by the necessity of having working interoperable solutions. Despite the inroads made by ERP vendors have made in developing mid-market and smaller firm models for ERP implementation, in this data set the Application Silos type remains the dominant means of seeking a degree of interoperability. We conjecture that this is principally because managers want to control their own data, and/or also because adapting to an ERP solutions later remains too costly. In many of these firms the principal application set was used for production management. Maintaining
production control was the critical, and immediate problem SMEs sought to address via the applications silos alternatives.

The logic of the second type, Partially Standardized Technology, is consistent observations made by Lynda Applegate at the 2009 ICIS where she emphasized that for small business partners and owners IT integration is considered essential by 80% of the firms she had studied in the United States. That is, to use systems resources that as are as standardized as can be so that increasing levels of integration can be achieved and easily and cheaply as possible. This type is the only place that we find the maturity curve suggested by Ross et al to accurately reflect the ways small companies grow an IT architecture.

The logic of the third type has been described in the literature by (c.f. Themistocleaous, 2002; Irani, 2003). To be part of this cluster of IT architecture types requires more resources only available to mid-size firms. It is interesting to note that while the firms in this cluster are larger than those in the other two type, the IT focus remains on interoperability and not the possibilities that might be afforded by having data warehouses and on-line analytical processing and data mining systems.

Findings in Light of the Research Questions

Finally, given our understanding of the data, and in light of the discussion above, we summarize the findings with regard to the initial research questions as follows:

Research Question 1: “What are the main IS architectures found in SMEs?”
Our taxonomy provides three types. The first two, Application Silos and Partially Standardized Technology are consistent with those described in the IT literature, particularly the work of Ross et al.. The third type has not been described in the earlier, large firm derived, typologies. We further find that the cluster into which an organization falls is likely to be governed by the interaction of a set of demographic (the firms age and size) and environmental factors. The environment factors include firm history regarding IT development and when IT integration opportunities that fit the organizations strategy and architecture actually became available.

Research Question 2: “What kind of systems integration approaches are present in SMEs?” We found that in SMEs the systems integration approaches were different from the mainstream and
idealized models representing large firm integration approaches (Markus, 2000). The first difference was that data warehousing was found to be largely irrelevant by this study set. We posit that this might be the case because in order to benefit from data warehousing technologies requires a certain reflexivity, sophistication and focus on continuous analysis with respect to historical data. It requires that they have to capture data in some organized and systematic fashion and have to mature towards obtaining strategic value from the ERP by system by adding complementary information (Holland and Light, 2001). This is a luxury few SMEs can afford. The second difference is that for these firms the primary goal is to have some measure of interoperability. It is the goal of operational interoperability that drives the evolution of the architecture and not some ideal of architectural integration. While the maturity model suggested by Holland and Light (2001) presents the ERP as the de facto (and becoming) standard, the Partially Standardized Technology is closer to becoming a dominant existing form at least with these SMEs. While it includes an ERP, this form nevertheless also includes the software bridges which, in a way, allow for the necessary business responsiveness and data protection.

For this set of firms it was clear that, for them, the immediate goal of interoperability prevailed over fuller, and more formal, system integration. Comparing the three IT architectures and IS systems integration types, the most common means for approaching any form of integration is via the construction of software bridges and interfaces. Given that Ross and Markus essentially disregarded the Software bridge/interface/API as a legitimate form of integration in the domain of the large organization, the fact that the software bridge approach dominates in the domain of the SME flies in the face of the canonical view. Let us be quite clear. *The means of achieving interoperability essentially discarded as an artifact of the past and of poor and unsustainable practice for the large organization remains the principle means of achieving some interoperability in the case of this set of small organization.*

**Study contributions:** The study contributions to research and to practice in five ways. First, in providing of a taxonomy of IS architectures and systems integration. This is important because, with the exception the Buonanno et al. (2005) comparative study of ERP adoption in large vs. small firms, until now we have been dependent on cases related to architectural or systems integration innovations without the benefit of having the description drawn from a reasonably
sized sample of SMEs. By exploring a population of firms we have been able to identify and describe meaningful similarities and differences between types identified and those suggested in the literature. In the process we believe we have also contributed to the clarification of nomenclature and of the many different definitions related to the “architectural” construct. The second contribution is that we have, following the challenge made by Orlikowski and Iacono (2001), taken the IS artifact seriously in this research. By studying architectural types according to their systems integration approaches we honored the technology artifact and by emphasizing its relationship between the technology sub-parts and considering those holistically i.e., the whole architecture and elements of the organizational context, we have illustrated the ensemble view of the IT artifact. The third contribution is that the results suggest reasons why architectures are not more integration than we might have expected. The fourth contribution comes from having examined how these architectural and systems integration forms arise in the SME and not the domain of the large-scale enterprise. This has allowed us to examine the proposition that the typologies arising form studies of large firms are somehow universally applicable to all firms. Indeed we find that this may not be true. The fifth contribution, one related to the practice of maintaining an IT portfolio, suggests that an IS manager considering the addition of IS resources must be aware of the type of IS architecture in place. This is so that the new resource be compatible with the extant systems integration approach and not be in conflict with the existing ecological infrastructure.

**Study limitations:** There are several limitations inherent in this study. Those arise from 1) the newness of the study, 2) the cultural setting and the sample of firms chosen for the research, 3) the sample, while being reasonably large, was nonetheless a convenience sample, and; 4) that the study conducted in 2002 before the widespread availability of business intelligence (BI) tools, Cloud Computing and Grid Computing within the firm.

With regard to the first limitation, empirical studies on enterprise integration architectures are rare, particularly in the arena of the SME. So as a first stab at describing and understanding IS architectures and systems integration typologies in the SME we had to adjust to surprises encountered at each step of the process. Regarding the second limitation, this is the first study of this type examining French firms. While we make no claim that the French SME is unique, we
also do not know of substantive cultural difference that prohibits theoretical generalization from these findings (Lee & Baskerville, 2003). These firms are, nonetheless, drawn from a single cultural backdrop. Thirdly, our convenience sample was targeted the midsize market of SMEs but we note that the mean firm size of our sample may exhibit a sample biased towards the large-medium size firms. Finally, there are suggestions that BI, the Cloud and The Grid may be making inroads even into the domain of the SME. We have no way to test that proposition with this data set. But given that other propositions drawn form the world of large firms does not seem to apply unproblematically to the domain of the SME, the only way we will know for sure is via further study.

Questions for further research

Although not explicitly tested in this study we sensed that, when there is no explicit or apparent integration strategy, management must somehow manage operational communication between applications. In general, for these SMEs, the use of IS tends to be operational in nature and focus and not strategic. For those firms that did have explicit integration strategies, typically the larger and older firms, we intuited a much higher degree of strategic alignment between the IS function and firm-level strategy, but even in these firms the pragmatic aspect of interoperability ruled the day. We think that empirical follow up work is required to test this question.

A related issue would be to identify possible paths from one type of architecture to another. That is, to answer the question: does a maturity curve exist for these organizations? Do firm strategies become more complex and sophisticated as they get older and larger, or, are there operational and environmental factors that play more important roles in the process? It also would have been interesting to have a complementary survey accessing the leadership role to see how this could influence architecture and enterprise architecture choices.

But one of the most intriguing questions we have yet to address, but is hinted at in this research, is the issue of why implementing an ERP may not lead to greater application and organizational level integration. Accordingly we posit two further questions for research as we gather and interrogate more data on these organizations:
1) Does implementing an ERP necessarily lead to greater either application level or organizational level integration?

2) Can we say that package software (Xu & Brinkkemper, 2007) necessarily means integration?

Finally, while we think that these findings can be meaningful in the EU as a whole the study was drawn from a set of regional French firms. But because current reports from the European commission suggests that the case of the small enterprise in France is typical throughout the European Union, and since the SME is a formidable and important economic force across the globe, it is our hope that these findings may be of general interest to managers both inside the domain of the European Union and outside Europe as well.
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