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**Forum on Strategic Management**  
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**ADAPTIVE TECHNOLOGY: A FOUNDATION FOR AUTOMATING**  
**THE TAXATION OF E-COMMERCE**

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**ADAPTIVE TECHNOLOGY: A FOUNDATION FOR AUTOMATING THE  
TAXATION OF E- COMMERCE  
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**In a special report, William Olders and Al DeVito of Data Kinetics Ltd., Ottawa, Canada, explain how adaptive technology can assist in taxing electronic commerce.**

**For technical reasons the diagrams are not reproduced in this document.**

William Olders is president/CEO and chief technical officer of Data Kinetics Ltd., Ottawa, Ontario, Canada. Al DeVito is chief operating officer.

1. As the popularity of the Internet has grown, so has the concern of tax administrations that the resultant rise in electronic commerce (e-commerce) will negatively affect the current tax collection process. Tax administrations in the industrialized world are very active in this area. Symposia have been held, committees established, draft policies enunciated, etc. -- all with the express purpose of ensuring that e-commerce transactions are taxed, are taxed fairly, and do not adversely affect our increasingly interlocked economies. Many tax administrations consider the issue one of the most difficult challenges they have ever faced. Will the current system of taxing commerce, a system based on a well-developed international consensus, be adequate to meet the challenge? What are the implications of the astoundingly rapid rate of technological change in both computer and communications technology?

2. The challenge for tax administrations boils down to one of coping with change. Tax laws are changing constantly. In the United States alone there are thousands of changes annually in the tax codes of its 30,000 taxing jurisdictions. Technology seems to change every month. Today's top-of-the-line computer is tomorrow's home computer. Yet, despite their changing legal and technical environments, tax administrations cannot wait until all elements of the puzzle are in place. They must begin now to craft a solution -- one that is fair, promotes compliance, and provides real-time feedback so that tax authorities can fine-tune the solution.

**What Is Adaptive Technology?**

3. Fortunately, there is at least one computer technology that can provide the foundation of a solution that will enable tax administrations to cope with their incredibly dynamic environment. This technology is known as adaptive technology. While it has not received the publicity of the "silver bullet" panaceas that are rife within the computer industry, adaptive technology has been used to create many highly sophisticated applications, from computer operating systems to currency trading. In particular, the technology has been used to great effect in building applications that cope with change -- applications that are able, without the need to be reprogrammed, to quickly adapt to changes in their environment.

Experience has shown that the use of adaptive technology as a tool in mastering change is limited only by one's imagination.

4. Adaptive technology is simple in concept. Essentially, it is based on the separation of business rules and processing logic. In some circles, it is known as rules-based or table-driven programming. While the concept of adaptive technology is quite straightforward, it has not always been successfully implemented. Why? It requires considerable experience with the technology, as implementation is not as simple as it first appears. One must be able to use the principles of abstraction to decipher the rules that govern the application and then devise a strategy to implement these rules. We will shortly look at some successful applications of the technology, few of which were the particular organization's first attempt at implementing adaptive technology.

5. But first, it is important to point out that adaptive technology can do more than provide individual tax administrations with a method to ensure that e-commerce within their jurisdictions is being taxed and being taxed fairly. As listed below, the ramifications of this technology are enormous.

1. A single, properly implemented, adaptive technology taxation application can meet the needs of all the taxation stakeholders (federal, state, city, and other local governments).
2. This single application can handle all non-income-based taxes (goods, services, use, consumption, occupancy, excise, retail, etc.).
3. Tax administrations can monitor -- in near real-time -- the results of policy changes and swiftly implement any necessary corrections.
4. Adaptive technology enables variable taxation per product and even variable taxation per product per usage, if that were the goal of the tax administration.

[Illustration omitted]

6. While rapidly growing, e-commerce is but one of our forms of commerce. E-commerce does, however, provide the almost perfect laboratory to develop a tax system for all commerce: it is the most complex domain, it is international in scope, the participants are "wired." Thus, a solution for the taxation of e-commerce as proposed here can be more generally applied to all forms of commerce, including conventional sales by local merchants. For example, in Canada today there is a great deal of effort being expended attempting to harmonise provincial and federal sales taxes. An adaptive technology solution is an ideal vehicle for reconciling the needs of the governments involved.

7. A properly designed adaptive technology solution for one tax administration can itself be adapted to accommodate the needs of other tax administrations. A common solution can be individually tailored for tax policy, language, individually targeted products, stakeholders, etc. -- without changing program logic or requiring a programmer to make the change; changes can be made directly by authorised tax policy officials. A common solution leads to significant cost savings in all phases of the creation of a system: implementation, deployment, and operation.

8. Clearly, the tax administration that develops the first adaptive solution will have the opportunity to recoup its costs -- and more -- by selling the solution to other tax administrations.

### **Examples of Adaptive Technology Solutions**

9. As we said earlier, adaptive technology is not new. It has long been used by forward-looking organisations around the world to develop critical applications that are used to gain competitive advantage.

10. Perhaps adaptive technology has seen the most use in the financial services industry. A large U.S. bank uses it in its marketing strategy -- its monthly customer statements contain a marketing message tailored to the customer based on his recent activity. A credit card processor can bring new banks on stream in a matter of hours through the use of adaptive technology. An international insurer automatically creates the changing daily workload of its administrative staff. A credit card company defines international credit rules dynamically to adapt to local market conditions.

11. An example of how the Canadian Anti-Inflation Board (AIB) used adaptive technology is particularly relevant to the issues facing tax administrations due to the rise of e-commerce, particularly with regard to the dynamism of the legislative and political environments. In the early 1980s, Canada established the AIB to monitor national wage and price increases. The challenge facing the newly created board was similar to that which e-commerce presents to tax authorities -- how to solve tomorrow's problems with today's tools. The board realised that it was embarking on a sea of uncertainty; however, it believed that a properly built computer application could guide it to its destination.

12. A computer application to monitor changes in wages, the primary driver of inflation, was built using conventional technology. It worked well for the first few months. However, because of the complexities involved in the reporting of the same wage changes by a variety of sources, the application soon became unworkable, eventually bringing operations to a virtual standstill and threatening the board's mandate.

13. The board decided to try a new approach -- adaptive technology. The first and most important step in this process was to move the business rules and most programming rules out of the program and into external tables. This brought several immediate benefits. Users could change the business rules directly by changing a table, resulting in faster turn-around times and lower costs. Program maintenance was reduced dramatically as a change in the table automatically changed the program's behaviour. Most importantly, the board was able to fulfil its mandate in a timely, cost-effective manner because they were able to cope with and master the dynamic environment in which they found themselves.

### **Components of an Adaptive Technology Solution**

14. The comprehensive solution for the fair and equitable taxation of e-commerce outlined in this paper requires both hardware and software components. And, most importantly, the tax authorities must provide the direction and support that can make the system a reality.

[Illustration omitted]

15. The first step that must be taken is the definition and acceptance of a protocol (the specification of a technology) that will ensure that, when a transaction occurs, all the information required to establish and collect the appropriate taxes will be available.

### **Hardware**

16. The widely available PC card (PCMCIA; see illustration of the concept, previous page) technology enables the storage of a vast amount of information, including a program, in a small, tamper-

proof package. The card cannot be corrupted by computer viruses; nor can data be inadvertently erased from it. The card is small enough to embed in common point-of-sale devices. Further, the card can be accessed by software through an open, widely recognised programming standard. Thus, the PCMCIA card would be the primary hardware component of the solution being proposed.

17. The card will contain, in a software agent, both the adaptive technology and a summary of all transactions. For security purposes, the card will also house authentication, encryption, and digital signature facilities. A security protocol, such as the SET (Secure Electronic Transactions) protocol supported by both Visa and MasterCard, could, through digital certificates and trusted third parties, be used to ensure the identity of the merchant.

## Software

18. The software agent will contain two types of functions:

- functions that make the transaction happen from a sales tax point of view; and
- administrative functions that the tax administration needs to do its job.

19. In the first category, the software, the tax agent, will:

- validate the parties to the transaction;
- identify the item, the tax jurisdiction, and any exemptions;
- flag non-compliant transactions for further action by tax authorities;
- calculate taxes due;
- collect and remit taxes due;
- flag items for customs' fast tracking;
- provide an audit trail;
- perform currency conversion and reporting; and be sensitive to the language(s) of the merchant-customer interface.

20. Let's look at a typical invoice issued by World Digital Products at the end of an Internet shopping session (see previous page) to see some of the workings of the software agent.

21. Item 1, the US Equities Market Survey, illustrates the use of an exemption by product type. In this case the survey was exempt from Ontario retail sales taxes; however, exemptions could be made for any other reason, such as the buyer having an exemption code of some type.

22. Item 2 shows how the system might handle situations involving an additional stakeholder, in this case the Canadian Copyright Board. The needs of all stakeholders, as embodied in agreements between parties, can be easily handled in the same manner. Note that this is an area where the proposed solution can be used to protect a nation's cultural heritage as well as intellectual property.

23. Item 3, Options Trading Seminar, shows that the proposed solution could pay the merchant directly and, thus, lower the cost to the consumer while, at the same time, implementing a government incentive to further one's education. Note the "Customs FastTrac" number. It denotes that the calculator was supplied by a foreign merchant and has been pre-cleared by Customs, reducing the processing at the point of entry and in most cases avoiding the costs of a clearing agent.

24. From an administrative point of view, the software will:

- automatically replicate tax policy changes to the appropriate electronic agents;
- automatically generate control information to verify payment streams;
- verify compliance using remotely controlled sampling techniques;
- automatically distribute e-commerce protocols defined by tax authorities to alter payment streams; and
- provide real-time aggregated feedback.

25. The importance of this last point -- real-time aggregated feedback -- should not be minimised. An example illustrates the point. A few years ago, the government of Canada, under pressure from antismoking lobbyists and concerned about the rising costs of health care, increased the tax on cigarettes dramatically. This caused smokers to seek an alternative, less costly (because untaxed) source of supply. Smugglers moved in to become that source of supply. The government had anticipated a certain level of black market activity but not to the degree that actually occurred. It was several months before the government was aware of the significant reduction in tax revenue caused by the smuggling activity. Had there been real-time feedback of what was actually occurring, the government could have taken the appropriate actions in time to prevent much of the revenue loss.

### **Mandatory Attributes of the Solution High Performance**

26. Adaptive technology requires extensive processing of tables. Because this processing is so intensive, adaptive technology requires an engine that operates at incredibly fast rates, preferably at computer memory speeds. This -- the need for high performance -- is another lesson one learns from failed attempts at implementing the technology. For example, a stockbroker substituted a conventional adaptive technology solution for one that was memory-based. The memory-based solution normally ran in a few minutes; the conventional solution ran for 26 hours before being cancelled.

### **Minimal Consumption of Computer Resources**

27. The fewer computing resources consumed, the more widespread the deployment of the solution, as it can be used in a wide variety of devices, even those common in the "mom and pop" corner store. A high-performance adaptive engine has been built to fit on a PCMCIA card, with plenty of capacity to store the taxation rules governing particular transactions and the transaction data itself. High performance is required to handle the billions of transactions that characterise global commerce.

### **Scalability**

28. The adaptive architecture that we envision needs to directly communicate with tax administration computers only for exceptional processing (such as exemption handling, rule updates, uploads of control data, etc.). Thus, the entire workload of the tax administration application can be distributed; some performed locally, some at the financial intermediary, some at the tax authority. Because the architecture can accommodate intermediate data collection and rule distribution hubs in order to redistribute the transaction workload of the central computers, the application is highly scalable, i.e., it can easily and quickly grow so that the needs of the largest, as well as the smallest, tax authority can be readily met.

### **The Solution in Action**

29. The solution being proposed acknowledges that there are two types of transactions that must be handled -- cash and noncash. The proper amount of tax must be collected in both instances. For cash transactions, the collection process will be handled directly by the merchant using the PCMCIA technology described above. Note that, as an additional benefit, the technology will also provide the merchant with an added level of control to reduce the cost of "leakage" in cash-oriented transactions.

30. For noncash transactions -- smart cards, credit cards, etc. -- the infrastructure to collect the tax is already in place. The financial intermediaries have the computers, the networks, the internal processes needed. All that needs to be added is the adaptive software application.

### **How Will the System Work?**

#### ***The Transaction***

31. Here's where the hardware makers come in, for the point-of-sale device has to accommodate the adaptive software component; i.e., each point-of-sale device would have a tax agent (software) attached to, or embedded in, it. All transactions are captured by the tax agent; this is mandatory for the success of any tax system. This capture and subsequent submittal to the tax authority is accomplished electronically over the network by those merchants with the capability. The "mom and pop" stores would simply send their tax agent housed on the PCMCIA card to the tax authority and receive a new one in exchange. For larger organisations that are already highly automated, with their cash registers tied into their corporate networks, portions of the tax administration software will be resident on their network.

32. Because transactions are stored in an easily retrievable format (provided one has proper authorisation), the appropriate parties -- tax administrations, merchants, etc. -- could be kept apprised of the current state of sales tax activity either through regular or ad hoc reporting mechanisms.

#### ***Establishing the Taxpayer's Jurisdiction***

33. E-commerce has the additional burden of establishing the jurisdiction(s) entitled to tax a particular transaction. Much has been written relative to the problem of establishing nexus in a global, borderless marketplace. It is not the intent of this paper to argue for or against any one approach. Adaptive technology can be used to implement any method for establishing nexus that a particular jurisdiction adopts.

34. It is clear, however, that whichever method of determining nexus is chosen, tax administrators must be able to rely on the accuracy of IP (Internet Protocol) ownership records and possess the ability to receive from any ISP (Internet Service Provider) the jurisdictional location information of a customer, whether the customer is connected permanently or transiently to the Internet.

#### ***Handling Exceptions***

35. What happens if a particular transaction does not fall under an existing tax rule? The same thing that happened with the Canadian Anti-Inflation Board case. It will be flagged as an anomaly by the system; the tax authorities can then decide what should be done. As part of the design of the system, the transaction

could be allowed -- with the PCMCIA agent making an "educated guess" about the tax to collect. If adjustments were warranted, the tax authorities could follow up using conventional methods.

### *Handling Change*

36. All changes (rates, categories, jurisdictions, payment streams, etc.) can be made directly by authorised tax administration staff. The changes can then be implemented automatically seamlessly, simultaneously, and immediately by simply downloading the changes to the PCMCIA cards and, for larger organisations, to the tax agent software resident on their networks.

37. Not only will this downloading capability reduce the cost to the tax administration of implementing changes in policy, it will lower the cost to the merchant as well, as all changes are made by the system rather than by the merchant.

### *Deploying the System*

38. The use of adaptive technology makes it easy for this system to be deployed. First of all, the system need not be implemented in one fell swoop. In fact, if experience tells us anything, it is that a system of this magnitude should not be implemented in any other way but in phases. Implementation of the first phase should be simplified because the significant participants are already "wired" to the Internet.

39. After a merchant has integrated the tax agent into his system, the agent is tax-neutral until it is activated. The activation, initiated by the taxing authority, would coincide with a normal accounting cycle of the merchant in which he ends the current process of voluntary compliance reporting and tax submission and begins the new automated process.

### *Ensuring Compliance*

40. With the proposed system in place, the compliance burden is transferred to a machine that is controlled and managed by the stakeholders. While the underground economy will always exist, the vast majority of taxpayers, for whom the system is being developed, are naturally compliant.

41. The basic problem in ensuring compliance is to know who is a vendor subject to tax in a particular jurisdiction. A "Web crawler," much like the intelligence-gathering component of today's Internet searching engines, could answer this question by constantly monitoring Web sites to determine whether commerce is being conducted. If the Web crawler finds that commerce is being conducted, it can determine whether the site is compliant or not.

42. The problem of compliance is particularly acute relative to the use of smart cards. In this case, compliance could be ensured by the adoption of a protocol for capturing tax information as the card is used. Legislative approval would likely be necessary to implement such a protocol.

### *Who Owns the Application?*

43. A key question in the effective automation of e-commerce tax collection is who owns the application -- the taxing authority, the merchant, financial intermediaries, or the taxpayer. While a partial solution can be implemented by any of the parties involved, it is our contention that, despite the overtones of "Big Brother" implied by government ownership, the taxing authority should own the application. An

all-encompassing sales tax administration system that can enforce compliance cannot be delegated to the taxpayer and be expected to work. Only a government- sponsored tax initiative that can:

- collect tax;
- distribute tax revenue to the appropriate stakeholders;
- streamline customs goods processing;
- return information quickly so that planning can be effective; and
- see the effects of policies the moment they are implemented will work!

### ***Not the Taxpayer or Merchant . . .***

44. If the taxpayer or merchant continues to own the problem, will we really achieve universal compliance? What are the risks of leakage when reliance for reporting is placed on the merchant or taxpayer? How quickly will the tax administration actually receive tax funds if it does not control the application?

45. How much of a tax expert can the merchant or taxpayer be expected to be? Can they be expected to know all of the tax rules of one jurisdiction, let alone those of more than one jurisdiction?

46. Can the taxing authorities demand that the taxpayer or merchant continuously change the collection procedures as the various taxing jurisdictions work out the details between themselves? We all recognise that this is an enormous and rapidly changing process. As stated previously, in the United States alone there are over 30,000 tax jurisdictions with thousands of changes annually. How can the taxpayer or the merchant keep up with this rate of change? What is their motivation to do so? Would compliance be increased if they were relieved of this burden?

### ***But the Government***

47. Although portions of the system are distributed and are under the care of the taxpayers, the governments should control the tax application. In fact, for the system to be most effective, the governments should actually own the application. If the people of a jurisdiction do not need to deal with the accounting hassles and the liability for mistakes, there will be a far greater acceptance, especially if they are assured that ongoing tax program changes are automatically effected without their involvement other than being passive custodians of government property.

48. Double taxation is a problem that can occur for a variety of reasons. In a centrally controlled environment these types of errors (or conflicts) are reported to the tax administrators for resolution prior to automated deployment.

49. The most far-reaching and longest lasting capability that this solution, if owned by the tax authorities, gives the taxpayer is a gateway to global resource management. The proposed tax administration system collects commerce information that can be used in the political process by stakeholders to arrive at consensus regarding a resource management issue. This allows communities and nations to arrive at consensus much faster via better-informed participants.

### ***Benefits***

50. The adaptive technology approach proposed herein is, we believe, the foundation for a tax collection system that will benefit taxpayers, merchants, tax administrations, and the body politic.

***The Taxpayer***

51. The taxpayer will see three primary benefits:
- Better value for his tax dollar Tax administration becomes efficient. Currently, the annual cost of sales-related tax administration in Canada, a nation of fewer than 30 million people, exceeds \$2 billion -- that is \$72 per person. Automating tax administration could eliminate the bulk of this cost. Leakage is reduced, resulting in potentially lower cost of goods. Goods pass through customs faster.
  - Better information. The taxpayer and the tax administrator can readily learn which tax jurisdictions are receiving what amount for what products and services.
  - Greater confidence that everyone is paying their fair share due to more universal compliance.

***The Merchant***

52. Fundamentally, the merchant saves money. He is relieved of a vast amount of paperwork and administration. He is immune from changes in tax policy, as these are downloaded by the tax authorities and are implemented automatically by the software. The collection and payment of taxes is either automated for bank card and smart card transactions or simplified for cash transactions.

53. In sales tax jurisdictions where the merchant receives tax credits for sales made to entities other than end customers the application can greatly reduce the cost and effort of dealing with this "reverse taxation." The solution proposed will eliminate this burden from both the merchant and the tax administration by automatically accounting for such situations.

54. The merchant is better able to meet foreign competition, which hitherto may have been able to avoid sales taxes and thus offer a lower price to the consumer.

***The Tax Administration***

55. The ability of the tax application to adapt instantaneously means that tax policies can be updated and changes implemented at the press of a button. And, with the system's real-time feedback loop, tax authorities would be able to see the effects of policy changes virtually instantly as well as effectively monitor the operation of the system -- all the while reducing the paperwork burden and gathering information to help pinpoint tax "cheaters."

56. A properly designed and constructed system will reduce other burdens as well. Verifying compliance can be considerably more of an automated process, and, thus, less costly than at present. The system as proposed can handle taxes for all types of commerce, not merely e-commerce; there will not be a need to develop additional systems or redevelop existing systems to accommodate changing conditions.

57. Most importantly, each tax administration can readily tailor the system to meet its goals. And, as stated earlier, the tax administration that develops the first adaptive technology taxation solution will be able to sell the solution to other tax administrations around the world.

***The Body Politic***

58. The wealth of information that the system provides will enable a more knowledgeable consideration of proposed legislation. Tax policies can be devised based on accurate and up-to-date patterns of commerce. Legislatures would be made aware, very early in the life of a new policy, of whether

the policy is working as well as its effect on the tax base. Taxes could be targeted at specific items, for example, to improve the environment or the public health.

### **Summary**

59. These are uncertain times. Tax laws and technology are in flux. Yet, each day e-commerce is more widely used. We must begin to craft a solution -- a solution that is fair, promotes compliance, and can adapt to an ever-changing world. We believe that adaptive technology is the foundation of such a solution. The benefits of the solution proposed herein are enormous. And, they are benefits for all of us. We must take the first step in developing the solution and define a protocol that will ensure that each transaction captures the information needed to ensure fair and effective taxes.

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