Bridging Global Divides with Tracking and Tracing Technology

Product-tracking technology is available to big players in the value chain that connects producers to consumers. Would creating a generic form of tracing technology for producers large or small level the playing field?

Ann Light
Sheffield Hallam University

In a small workers' hut in Chile, pinned up by the window looking out at the vineyard, is an A4 typed list from a major British supermarket chain with precise requirements explaining the grower's accountability for its crop and what it must be able to do in terms of tracing if its product should ever need recalling. There is no computer or printer in this hut, in this field outside Curicó where all one can see for miles is vines and blueberries, the grower's other crop. I am visiting from England, and it is strange to see this familiar shopping logo amongst the Spanish words, the handwritten notes, the clutter of everyday life in this little room where staff gather for lunch and to plan their schedules.—account of field visit to Chile, Fair Tracing project, Nov. 2007

Digital technologies are increasingly set up to link worlds: producers and consumers, town and country, industrialized and developing regions, tiny suppliers and major corporations. The frequent assumption is that the networks will be enabling: they'll join disparate places, people, and things, supporting connection anytime and anywhere.[1] However, big global players with dedicated teams seeking efficiencies and the R&D facilities to do the research most often devise new commercial practices, with no reference to smaller producers' needs. Particularly in commerce, which runs over a global socioeconomic network, technology-based innovations have impact worldwide and are impossible to ignore, even if they're unavailable locally. Moreover, many technologies aren't available locally in a form that provides access to the small producer, who might face financial and organizational barriers to adoption.

In theory, it should be possible to supply a version of tracking technology to anyone who wants to use it. Already, certain data travels whenever a product is made, transformed, or changes hands. Money goes one way; materials go the other. But, much of that information isn't in portable form. When it comes to labeling goods so that they're easier to track and trace, the system is more complicated than just the circulation of goods, information, or money alone. Characterizing identity management for the supply chain of the future, one Wikipedia entry quips that "the idea is as simple as its application is difficult" (http://en.wikipedia.org/wiki/Automatic_identification_and_data_capture).

This article explores what the mix of simplicity and complexity means for equipping small businesses in emerging economies. The examination will focus on the Fair Tracing project, my team's experience with two producer partnerships and how they helped us understand which aspects of labeling products would be easy to

Published by the IEEE CS ■ 1536-1268/10/$26.00 © 2010 IEEE

integrate and which might prove resistant. Our partners—producers of fair trade wine in Chile and shade-grown coffee in India—were enthusiastic to tell marketing stories in a way that associated their narrative with individual items, rather than a brand. So, we were privy to some first-rate local information about what a tracing system's content and process might involve.

More specifically, the Fair Tracing project examined whether a tracing system along the value chain could be of more than just commercial interest. Could it also lead to feedback systems of good production and consumption practices? Previous work[2–4] has covered the technical aspects of tracking, so this article concentrates on the sociotechnical viability of implementing a worldwide product-tracing system. In addition to tracking product progress, this system would support transmission of social, economic, and environmental data.

Although the focus here is technologies of tracking and auto-identity for products in the value chain,[5] engineering accounts alone often leave out key political and cultural aspects. This article thus also explores related barriers to more widespread adoption. Different organizations and communities have different orientations to international commerce and digital technology, but this discussion is primarily concerned with the pragmatic roadblocks to uptake, even when organizations have the opportunity to adopt their own version of the technology. (For the purposes of this article, *tracing* is the activity of presenting end-to-end information on production to all stages of the chain, including the consumer. *Tracking* is logistics management of products along the chain and has no public element.)

The Fair Tracing Project

Fair Tracing (www.fairtracing.org) was a UK-led project researching a tool to support trade across different global contexts: linking small rural producers in developing regions with the affluent, predominately urban, consumers of northern Europe. This ethical dimension was inherent in the research project. Transparency alone would benefit these smaller producers, making goods visible to consumers, giving producers access to commercial information, and revealing value-chain relationships.

This dimension is relevant in considering that the tool was intended to extend beyond tracking to tracing. Material might include details ranging from economic and environmental costs, working environments, and salary to information on transport to the consumer point-of-sale. We hoped to automate some aspects of this data transmission, while encouraging the actors along the value chain to create audiovisual and narrative material. Indeed, in the Web 2.0 paradigm, even consumers might find a new role in purchasing and consumption as co-creators, offering ratings, feedback, or more imaginatively their own video diary of use. Digital technology could not only store and transmit this new data with specific products, but it could also link it to provide transparency about each contribution's author through authentication.

Most important here, through the Fair Tracing project, we aimed to research implementation and potential use in context, beyond individual technological components and the tidy structures of big business where such tools are already finding a home. Consequently, much of the job was to engage and work with producers along representative value chains, exploring with them their production and information-gathering processes and considering the implications of a new form of data creation and management.

> In addition to tracking product progress, the tracing system would support transmission of social, economic, and environmental data.

The Fair Tracing Tool

The Fair Tracing project investigated the feasibility of introducing a public Automatic Identification and Data Capture (AIDC) tool for use worldwide as a distributed hub between value-chain members and consumers. (For details on AIDC, see the "Automatic Identification and Data Capture and Its Consequences" sidebar.) Using the Internet and peer-to-peer connections to create robust and low-cost connections, such a tool could store and generate chains for any product for which people were prepared to enter data. A Web application would accept data from anyone anywhere on a chain, labeling it with its source to make its relationship to the chain transparent. The application would then represent the data on users' chosen devices.

We anticipated that, by being available to all, the tool would help producers compete with or plug in to new accountability systems, while helping consumers find information about products. Tom McGuffog describes a value chain as a series of sequential events bounded, identified, and ordered in terms of time and duration between transitions.[6] Given that definition, we assumed the result would be tractable to a broad range of conditions. But how would such a system work in the wild?

Method

The project worked with two supply chains representing small and micro producers in developing economies: wine in Chile[3] and coffee in India.[7] The Chilean wine supply chain had fair

Automatic Identification and Data Capture and Its Consequences

The identity management, tracking, and promotion of goods using Automatic Identification and Data Capture (AIDC) along the value/supply chain appear in many guises and have been developed to give its users better product control. However, at present, because of the scale needed to undertake it, AIDC has become a technology that largely benefits an exclusive tier of manufacturers and distributors.

AIDC Technology and the Value Chain

Tom McGuffog describes the operation of a typical value chain, comprising the

- chain's participants and their locations,
- items (products and services in their various forms),
- processes (rules, treatments, recipes, and so on), and
- assets.[1]

This identification should

> *be achieved via the smallest practical number of globally accepted systems of numbering, preferably employing unique and non-meaningful identities … [and] the ID numbers above should be expressible in a form which can be automatically captured, wherever cost-effective, for example by laser scanning of a printed symbol (barcode), radio frequency identification of a tag (RFID) or by reading a smart card with a Personal Identification Number (PIN).*[1]

McGuffog's breakdown of a value chain into functional components gives us a useful overview of the event-based method of creating such a system and the types of technology in use to support it.

At the same time, research is taking place to better apply tracking (such as with RFID reliability)[2] and tracing[3,4] to the value chain. Smaller dedicated enterprises exist, such as Historic Futures (www.historicfutures.com), which already promises to track any batch from production to distribution for collaborating organizations and offers information including product miles and water and energy use. However, there's a disconnect between the researchers' idealized proof-of-concept conditions and the world in which suppliers, manufacturers, and distributors ply their trade.

A quick overview of the literature on supply chains shows that they aren't representing the consistent and unambiguous relationship that the neat flow of much test data suggests. Depictions of commerce can vary widely, conveying different understandings of the same business practices and suggesting different patterns of engagement with the wider sector, as Susan Lambert writing on business models, notes.[5] In fact, the only constant seems to be some network of interdependent agents organized over time and space and showing flexibility and dynamism through which products move one way and money moves the other.

Who Benefits from AIDC?

The advantages to AIDC users include efficient production, distribution, theft reduction, and accountability. The companies

trade certification and a simple value chain. Conversely, the Indian coffee industry is in a state of post-deregulation economic readjustment and has complex paths to market.

In seeking producer groups for collaboration, we decided to build relations as full partnerships. This meant bringing in producer representatives as informants in an investigation of feasibility and desirability and asking them to consult on ideas, partial prototypes, and potential uses. The method involved setting up a collaboration agreement and including the partners in relevant stages of project discussions. For instance, through design workshops, partners helped determine what information is gathered, what information participants could gather, and what the overheads would be.[3] We commissioned local academic researchers to be the local link at the chain's starting point.

Given that an entire working tool wasn't going to materialize in the project's lifetime, we also closely examined the time commitment we were asking of the producer partners and what the recompense might be. On a side note, we did provide our partners with information we gathered on consumer behavior to support their marketing activities. Additionally, to make the material relevant at the consumer end, we performed considerable work that focused on international (British) and domestic (Indian) consumer opinion and behavior.

Having built a relationship of trust, together with our partners we scoped use of information and communications technology (ICT), which involved auditing processes in what were, in effect, two contrasting case studies through contextual interviews with key staff. The staff demonstrated how they conducted business and communicated with others. By following the product around and focusing closely on the passage of information, we were able to gain a sense of possibilities and elicit our partners' views on and knowledge of the value chain.

employing AIDC tend to be major manufacturers and distributors of goods. The advantageous bargaining position that comes from their scale and relationship with the market means that they can introduce AIDC and require cooperation from suppliers, who then enter production data as part of maintaining a commercial relationship. However, little motivation exists for making information available up the chain toward independent suppliers.

Least likely to benefit are the many suppliers based in the world's developing regions, where access to technology lags. The smallest of these producers, small to micro enterprises, have the fewest resources to manage their output and negotiate for either information or profit. Because they operate at near-subsistence level, they're also likely to have the least knowledge of the wider chain. Most of their effort goes into the immediate production cycle.

At the other end, this complex network of global trade is also usually invisible to consumers. Indeed, many consumers have no idea about the origins of their purchases: where they come from, how they start life, or who makes them. New labeling practices acknowledge consumers' interest in country of origin, but the appetite for information is growing. With increased tracking, the means exist to make this data available more generally as part of product information—that is, to make goods traceable.

This research area has become fashionable, with an increasing number of student design projects for consumer information systems, particularly addressing environmental issues. What distinguishes the work in this article from these other projects is the emphasis on production, the extensive work we conducted with producers of these goods, and the interest in tying the two ends (with the various stages along the chain) into one system.

REFERENCES

1. T. McGuffog, *Diamond—How to Add Strength and Sparkle to Your Value Chain: A General Theory of Value Chain Management Data*, UK Partners for Electronic Business, 2004; www.ukpeb.org/ukPeb-0023-04(Diamond_).pdf.
2. A. Rahmati et al., "Reliability Techniques for RFID-Based Object Tracking Applications," *Proc. IEEE/IFIP Int'l Conf. Dependable Systems and Networks* (DSN 07), IEEE Press, 2007, pp. 113–118.
3. C. Plate et al., "Recomindation: New Functions for Augmented Memories," *Adaptive Hypermedia and Adaptive Web-Based Systems*, LNCS 4018, Springer, 2006, pp. 141–150.
4. J. Neidig and P. Stephan, "An Object Memory Modeling Approach for Product Life Cycle Applications," *Ambient Intelligence and Smart Environments: Workshops Proc. 5th Int'l Conf. Intelligent Environments*, IOS Press, 2009, pp. 27–32.
5. S. Lambert, "A Review of the Electronic Commerce Literature to Determine the Meaning of the Term 'Business Model,'" School of Commerce Research Paper Series: 03-5, 2003; www.flinders.edu.au/socsci/business/research/papers/03-5.pdf.

For example, we went to the coffee plantation in the Koorg hills, watched the production stages, and visited the curing works that grade most of the region's coffee (from the larger plantations or trader-aggregators, who buy from smaller growers). We examined the chits that traveled to and fro with pregraded and graded coffee beans and studied the recording systems in use (see Figure 1 for an example of grading classifications from a batch of coffee). If high-quality coffee came from producers large enough to carve their own path to the distributor, it received the "specialty" brand. If it came from smaller producers with less control over their product, it tended to end up as instant granules because the individual quantities were too insignificant to merit their own branding. On top of the impact of the different route to market with its extra legs, this less stylish destination had financial implications for smaller producers.

The design workshops created a forum to collaboratively identify production processes, assess how willingly locals would collect and share stories, and brainstorm means of turning knowledge into representational material. We also discussed partners' interests and needs in considering a tracing tool. This work let us build prototype interface designs for different platforms, such as Web and phone, and revisit them to test these designs with our partners. However, the interface designs, which showed a map, a timeline, and a social network, stayed at the conceptual level. Because we were interested in automatic data capture, the focus wasn't on interaction design for data entry. Rather, the designs tested how those whom the data represented would respond to our presentation of it. (Other work documents interaction at the interface better than we can within this study's scope.[8])

We collected most data through semistructured contextual interviewing and some limited ethnography with our business partners. To some extent,

Figure 1. Sampling coffee grades. Staff at the curing works grade a batch of coffee into different classifications. In February 2007, the Fair Tracing project studied the processes at plantations in India and the next steps in the supply chain.

the final methods were a compromise between methodological intentions (following many of Andrew Dearden and Peter Wright's processes[9]) and the practical business of fitting in with a working organization. We recorded the workshops in video files and most of our other exchanges in audio files, though we captured some sensitive speculative meetings only in written note form. We also made records of our own planning meetings.

Analysis involved groups of researchers extensively reviewing notes and recordings in data sessions together and creating visual representations to organize relationships and information. For instance, Figure 2 shows two visual interpretations of the wine journey. In Figure 2a, the interaction designer's drawing depicts the actors (people and their ICT) as a way for the research team to consider the limitations of the collective's resources. Figure 2b, created for external discussion purposes, more formally shows political entities along the chain and how we interacted with them. Because the Fair Tracing team represented the part of the knowledge bridge that connects producers to consumers across cultures, this analysis was critical for both shaping discussion about what the Fair Tracing tool might become and reporting on the project.

Collecting and Representing

The partner in Chile was the Los Robles wine collective and its owners, 44 vineyards of varying sizes. (Incidentally, the collective dissolved in 2008 under economic pressures.) This relationship meant that key state changes, from fruit to liquid to bottle, took place close to the source. As wine producers, the collective had to meet European and American supermarkets' stringent accountability demands. Grapes also have associated information, but tracing grapes in their passage to wine might be a more suitable challenge for biotechnologies, rather than current AIDC implementations.

This article opens with a description of a field visit to explore the winery's audit trail. The logistics manager handwrites codes into ledgers that associate each bottle with a production date, a fermentation vat, and a grape batch. A dedicated wine database, called Kupai, captures information about the wine's mix and quality and lets the management team view growers' output as one of three quality categories. However, quality assurance staff—distinct from the oenologist who mixes the blend—use a separate structure based on Microsoft Word documents, again printed and stored. In other words, using ICT for mapping the collective's supply chain involves multiple types of records through which information can't pass seamlessly (see Figure 3). Moreover, only some records are in a format that users can manipulate.

The growers, too, move between spreadsheets and ledgers. Thus, although the collective's employees were interested in a marketing tool for communicating with consumers, they talked about tracking technologies. They saw a means of putting data into a Fair Tracing tool from each production stage and, in so doing, bypassing their internal systems' fragmentation.

The collective was one context into which we discussed introducing tracing. The other, the coffee growers, was more fragmented and even less dependent on software for communication.

Barriers to Use

Working with producers as partners in situ revealed that, in addition to the technical implementation's complexities, many sociotechnical issues need resolving for the Fair Tracing tool to become useful. These examples demonstrate the challenge that adopting this kind of technology might raise for organizations managing in constrained circumstances with fewer resources than the businesses for which AIDC was developed.

Inputting Data

The smallest producers are mostly operating without access to digital technology or the level of software skills

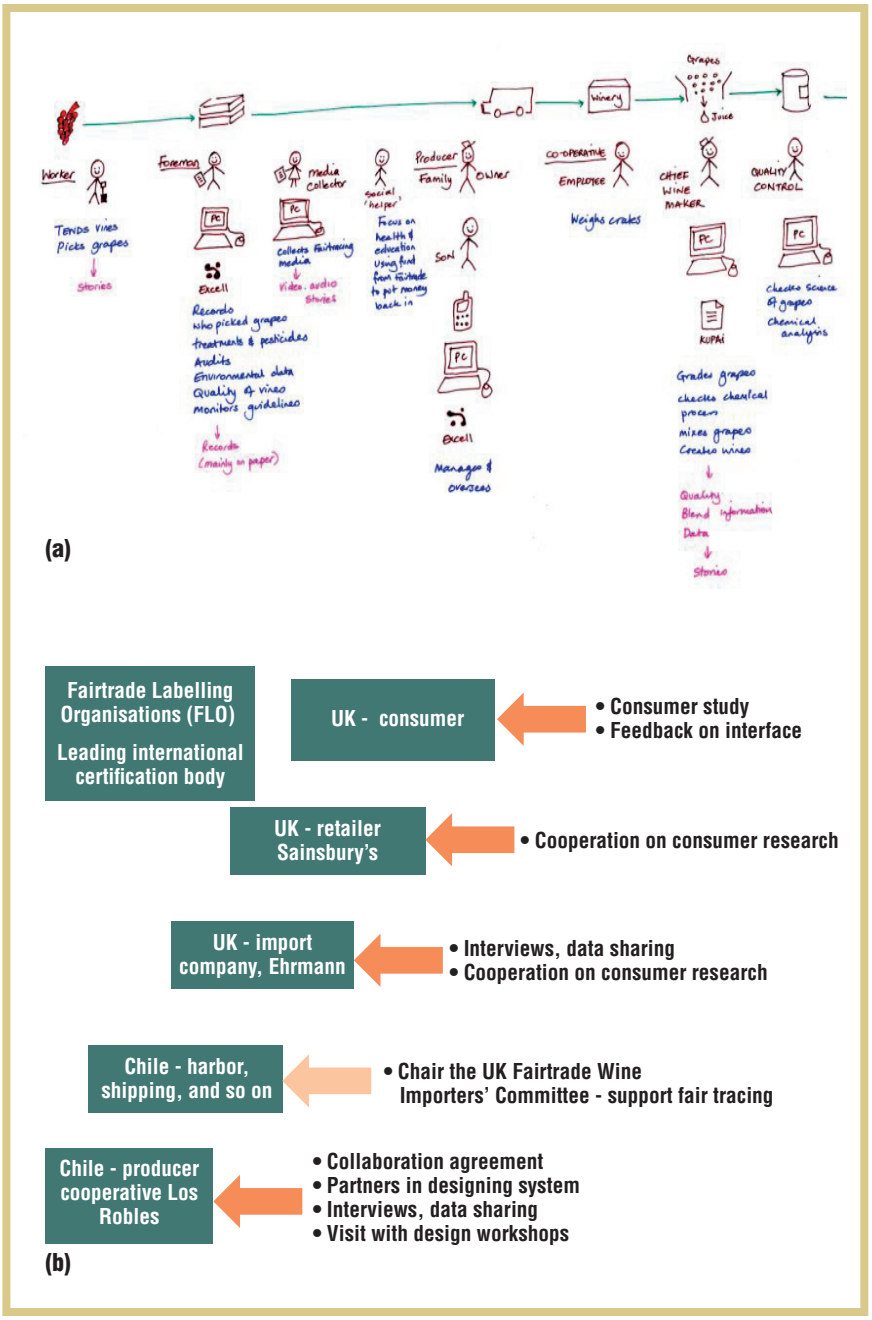


Figure 2. The wine journey. (a) A drawing of the processes through which grapes pass at the Los Robles bodega in Chile. (b) The value chain for wine developed through interviewing key actors. (Courtesy of Helen Le Voi and Dorothea Kleine, respectively; used with permission.)

and access that makes capturing data automatic. Paper trails follow both products: the coffee producer's handwritten chits and the wine collective's Word documents for printing and distributing.

Good interaction design practice asserts that asking staff to enter codes by hand to identify individual items is laborious and error prone.[9] Without these identifiers, no automated system can attach metadata to products. Moreover, producers lack the budget to introduce the hardware, software, and training needed to use spreadsheets to make data capturable throughout production.

Collecting Relevant Information

Another problem is collecting information to use as metadata. Particularly in a context in which producers can show off practices publicly, the amount of production data needed extends beyond that which businesses find necessary to keep. In their business records, some coffee growers record only price per unit and quantity. The wine collective finds itself obliged to do more record keeping. It's accountable to distributors for identifying any batch if the need arises. Additionally, because of their collective structure, the wine producers keep more information on production costs than many of the farmers in India do. Individual growers collect and use data on quantities of fertilizer and insecticides for grapes, for instance, but such details would interest only the most fervent consumers.

In both chains, collecting further data would increase overhead and potentially introduce issues of basic media and digital literacy. Indeed, the indifference some of the Indian coffee growers showed in interviews to the prototype interfaces' information-design features suggests that the challenge to communicate across the Web goes beyond equipment. Yet, a public appetite has developed for knowledge about everything from electricity costs per unit to means of transportation to packaging price and source. The data that producers collect doesn't match the data their consumers want.

Managing State Changes

Identity management requires an identity, but it's not straightforward to determine what makes a discrete unit for AIDC purposes. Whereas grapes leave the collective as wine bottled with a code recorded in a ledger, the Indian

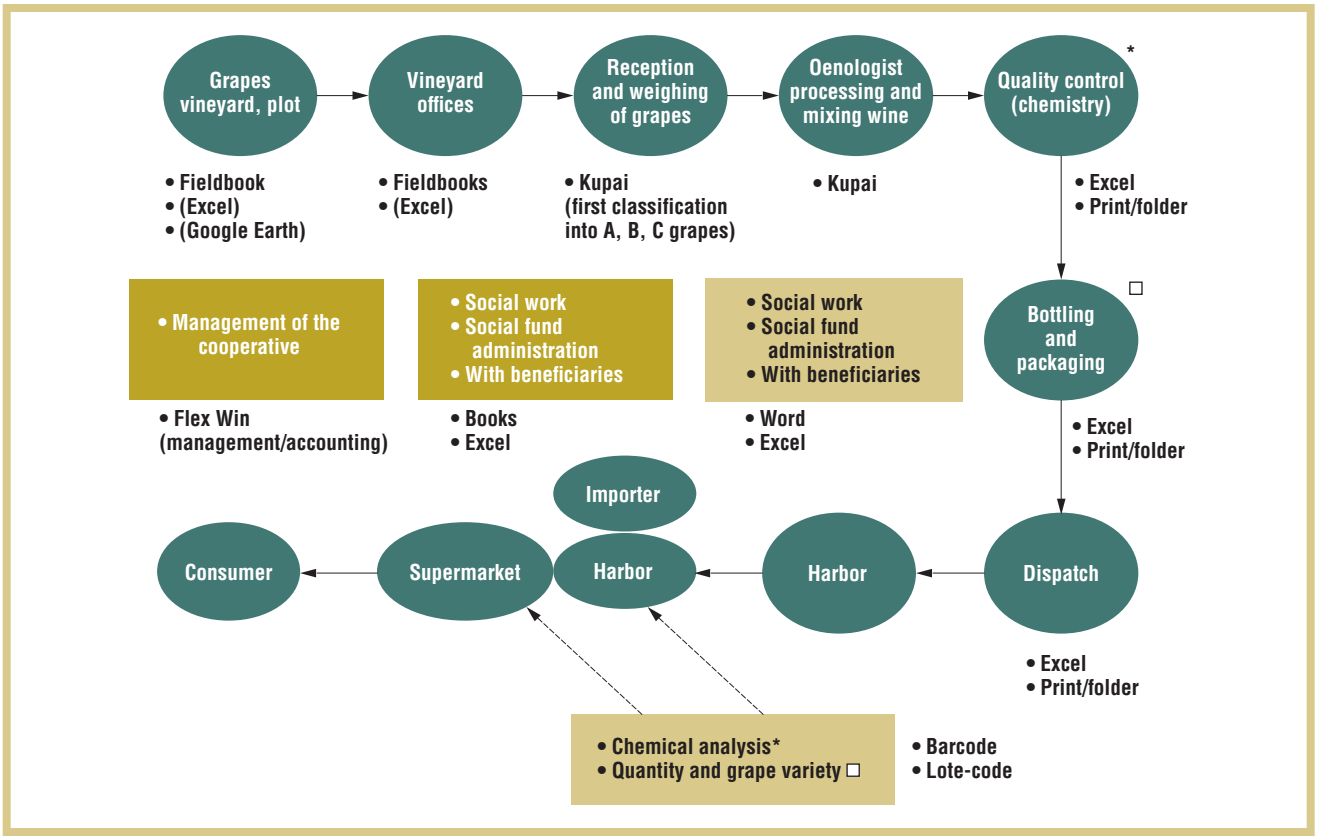


Figure 3. Los Robles winery's information flow and formats. The multiple record-keeping formats prevent the information from passing seamlessly through, and out of, the wine collective. (Courtesy of Dorothea Kleine; used with permission.)

coffee sector presents a more complex scene. Multiple fragmented entities contend as principal units: coffee cherries off the bush, sacks of stripped beans from a plantation, or the pile of graded beans at the curing works. Consumers see a packet of roasted grounds or jar of instant coffee at the supermarket.

Between the bean and the cup exists a series of product transformations as beans are stripped, graded, roasted, ground, and packaged, all with associated data translations. These processes, which are in the hands of various parties for social and political reasons, are more convoluted where big business hasn't intervened to streamline them. For smaller producers, identity ends at the curing works, where their product combines with a pile of the same grade. To avoid the taxes (an extra 25 percent) incurred if they take their crop to the curing works themselves, many producers sell to traders at the plantation gate before grading. This practice introduces further fragmentation of processes, knowledge, and control.

Politics along the Chain

Power relations play a significant role along the production chain. They affected the case study partners' willingness to be involved in the project,[4] for example, with each player needing sign-off from further along the chain before agreeing to participate. Moreover, small producers were most vulnerable to importers' and distributors' demands.

Among other consequences, these politics influence what information partners can make public. For instance, both the fair trade wine producers and the coffee producers, whose product quality wasn't exploited, were keen to show how they divvy up profits. This is interesting data for consumers to assess but a controversial topic to display. In other words, collating this information might be hardest for those with the greatest interest in displaying it. Because strong dependencies exist, producers might feel constrained to tell a politically conservative story for fear of offending distributors and those further up the chain, making it awkward to share facts that would otherwise be in the suppliers' best commercial interests to make public.

The issue also arose in the context of packing material: an option that a supplier found preferable and more environmentally sensitive, a distributor found less convenient. Likewise, another story likely to go untold involves the tension small producers experience between pleasing the chain actors and pleasing the consumers.

Understanding the Commercial Context

Although basic AIDC requires only unique numeric identifiers to manage transitions and track products, the enhanced model with shopping data might include multimedia or text presentations for consumers. This enhancement introduces translation issues and their attendant overhead—for example, the wine collective produces information in Spanish, but its international audience wants English or their local tongue.

At another level, different values and practices manifest in different cultural expectations across the world. Producers need a sense of their market and how to target domestic and foreign consumers. Again, marketing knowledge more often belongs to larger, more cosmopolitan operators who can travel themselves or afford to employ specialists. In the project, we witnessed this factor during discussions about how to show a content provider's authenticity. Although consumers expect YouTube aesthetics from working people, producers were keen to adopt high-end media values for fear of looking inadequate. So, they abandoned the competitive advantage of looking "real."

Third Parties

Many smaller producers face the additional complication of depending on third parties for some of their identity or relationship with the chain. Agencies such as the Fairtrade Labelling Organizations International (FLO), which certifies fair trade products, or Oxfam, which supports micro enterprises worldwide, play a significant role for suppliers such as the wine collective.

These key third parties are difficult to bring into the value chain using an event-based coding system. It would probably fall to motivated producers to enter their details (adding overhead), unless third parties adopt the process of constructing and making visible chains for associated products.

Discussion

Sorting out the technical aspects of small producers adopting either a tracking or tracing tool is necessary but not sufficient in making it available. The Fair Tracing project's intention was to learn how to produce a generic Web 2.0 tool of use to anyone: a device that any organization, regardless of size, could plug in to its systems and use to broadcast data.

One Size Doesn't Fit All

A generic tool doesn't seem to be the answer. Instead, the tool must take into account producers' circumstances and the wider contexts in which they operate and possibly the nature of the goods. Lone suppliers can conduct exchanges with consumers and offer handmade marketing; however, they can't capture data and assemble it in such a way that the chain emerges, unless they're particularly well equipped and dealing with a simple, controllable product. Many producers would have to become more media and marketing literate to benefit fully from the range of commercial advantages a tracing system could provide.

Following the Fair Tracing project, the Karnataka coffee industry (including even the smaller producers) showed considerable interest in tracing and discussed modernizing processes to introduce the practice.[4] Led by state government-backed trade bodies, the industry sees RFID as one vision and biotagging as another. Because tracking is a prerequisite to tracing, this modernization, though, might result in workers entering long strings of identifiers all day to attach codes to batches of coffee. Indian coffee plantations might find that the salaries of numerous workers might be less overhead than introducing mobile spreadsheets and networked databases. Furthermore, many workers see these mundane jobs as offering the skills that let them progress to more interesting work.

The outcome of the interest in Karnataka won't be a generic tracing tool for use with any product by consumers worldwide; it will be for Indian coffee. This result demonstrates the continuing importance of the social structures around digital networks. The politics are inescapable. Indeed, there's talk at the trade-body level of using the system to highlight and remove small traders in the coffee chain who take profit without adding value. In this scenario, the software drives social changes, with negative consequences for those outside the sector and the promise of an improved business for those within.

A Custom Solution and an Intermediary

Considering the Fair Tracing project's communicative goals suggests the benefit of working with the right intermediary to help populate and possibly federate this type of system.[10] For producers with little software, marketing, or direct sales experience, an organization with the role of bridging and brokering would seem crucial. Such an organization would serve as an intermediary who sees and demonstrates to producers the value of selective overhead to ensure consistent value at the consumer end. Additionally, it would be able to post data about the chain without risk of losing business. This candidate could be an existing organization, such as FLO; a trade body or

A generic tool doesn't seem to be the answer. Instead, the tool must take into account such factors as producers' circumstances.

the AUTHOR

Ann Light is reader in interaction, media, and communication in the Communication and Computing Research Centre at Sheffield Hallam University and visiting researcher at the University of Sussex and Queen Mary, University of London. Her research interests include technology's social impact and the politics of participation in design, human–computer interaction, cross-cultural methodology, and interactive media and design. Light has a DPhil in computer science and artificial intelligence. She's a member of the ACM and the British Computer Society's Interaction Special Interest Group. Contact her at a.light@shu.ac.uk.

new collaboration, such as a collective; or a major player in the chain with the right corporate social responsibility agenda.

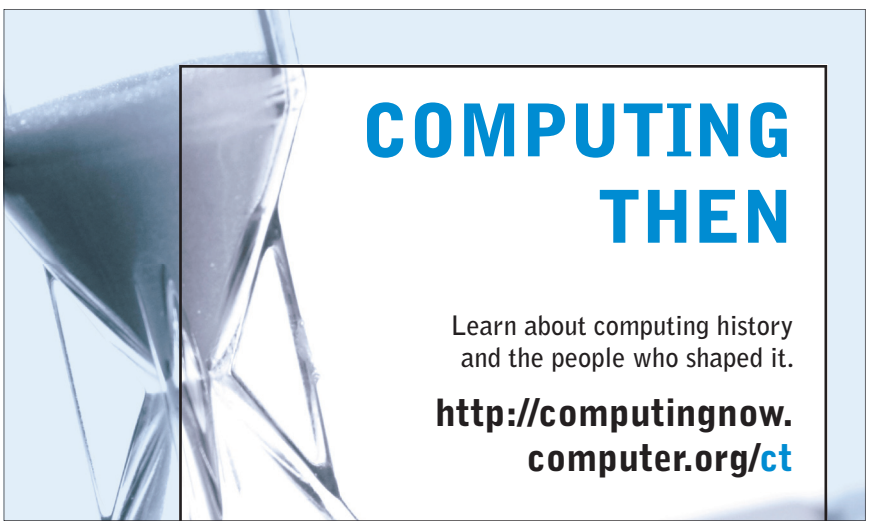
The key challenge for such an organization would be to avoid introducing additional overhead and power structures that don't increase value for the smaller players. Introducing an intermediary doesn't remove the challenges of cross-cultural interaction,[3] it resituates them. Anyone tackling the role would still need to consider which languages to use and whose values to reflect so as to appeal to consumers in other parts of the world without alienating the organizations along the production chain.

Although consumers are ready for a generic product information tool, it's a long way from plug and play for those who would be creating the value of it by inputting the data. Nonetheless, as tracing has benefits, so would developing the social and financial structures that support small suppliers in following their goods along the chain. A fair tracing tool might then be the aggregator of any data that producers could make public for marketing purposes and building on logistics management.

The impact of networks is particularly powerful in the economic realm, underpinning the very idea of currency. Even making producers aware that they're being left behind as new technologies are developed into powerful tools can be a force for change. ■

ACKNOWLEDGMENTS

Thank you to the Engineering and Physical Sciences Research Council for funding and to Fair Tracing's Ian Brown, Ashima Chopra, Dorothea Kleine, Apurba Kundu, Helen Le Voi, Cote Montero, Macarena Vivent, and Christian Wallenta for their work.



REFERENCES

1. *ITU Internet Reports 2005: The Internet of Things: Executive Summary*, Int'l Telecommunication Union, 2005; www.itu.int/osg/spu/publications/internetofthings/InternetofThings_summary.pdf.
2. M. Jones et al., "Stepping In: An Outsider's Guide to Crossing the 'Digital Divide,'" *User Experience*, vol. 8, no. 3, 2009; www.upassoc.org/upa_publications/user_experience/past_issues/2009-3.html.
3. A. Light, D. Kleine, and M. Vivent, "Performing Charlotte: A Tool to Bridge Cultures in Participatory Design," *Int'l J. Sociotechnology and Knowledge Development*, vol. 1, no. 2, 2009, pp. 36–58.
4. A. Light and T.D. Anderson, "Research Project as Boundary Object: Negotiating the Conceptual Design of a Tool for International Development," *Proc. European Conf. Computer Supported Cooperative Work* (ECSCW 09), Springer, 2009, pp. 21–41.
5. M.E. Porter, *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press, 1985.
6. T. McGuffog, *Diamond—How to Add Strength and Sparkle to Your Value Chain: A General Theory of Value Chain Management Data*, UK Partners for Electronic Business, 2004; www.ukpeb.org/ukPeb-0023-04(Diamond_).pdf.
7. A. Chopra and A. Kundu, "The Fair Tracing Project: Digital Tracing Technology and Indian Coffee," *Contemporary South Asia*, vol. 16, no. 2, 2008, pp. 217–230.
8. S. Patnaik, E. Brunskill, and W. Thies, "Evaluating the Accuracy of Data Collection on Mobile Phones: A Study of Forms, SMS, and Voice," *Proc. Int'l Conf. Information and Comm. Technologies and Development* (ICTD 09), ICTD, 2009, pp. 74–84.
9. A.M. Dearden and P.C. Wright, "Experiences Using Situated and Non-Situated Techniques for Studying Work in Context," *Proc. Int'l Federation Information Processing TC13 Int'l Conf. Human–Computer Interaction* (Interact 97), Chapman & Hall, 1997, pp. 429–436.
10. A.M. Dearden and A. Light, "Designing for e-Social Action: An Application Taxonomy," *Proc. Design Research Soc. Conf.*, 2008; www3.shu.ac.uk/Conferences/DRS/Proceedings/Proceedings.htm.