15 Electronic Commerce

A web-intensive business's *clickstream* data records the gestures of every web visitor. In its most elemental form, the clickstream is every page event recorded by each of the company's web servers. The clickstream contains a number of new dimensions, such as page, session, and referrer, which are not found in other data sources. The clickstream is a torrent of data; it can be difficult and exasperating for DW/BI professionals. Does it connect to the rest of the DW/BI system? Can its dimensions and facts be conformed in the enterprise data warehouse bus architecture?

We start this chapter by describing the raw clickstream data source and designing its relevant dimensional models. We discuss the impact of Google Analytics, which can be thought of as an external data warehouse delivering information about your website. We then integrate clickstream data into a larger matrix of more conventional processes for a web retailer, and argue that the profitability of the web sales channel can be measured if you allocate the right costs back to the individual sales.

Chapter 15 discusses the following concepts:

- Clickstream data and its unique dimensionality
- Role of external services such as Google Analytics
- Integrating clickstream data with the other business processes on the bus matrix
- Assembling a complete view of profitability for a web enterprise

Clickstream Source Data

The clickstream is not just another data source that is extracted, cleaned, and dumped into the DW/BI environment. The clickstream is an evolving collection of data sources. There are a number of server log file formats for capturing clickstream data. These log file formats have optional data components that, if used, can be very helpful in identifying visitors, sessions, and the true meaning of behavior.

Because of the distributed nature of the web, clickstream data often is collected simultaneously by different physical servers, even when the visitor thinks they are interacting with a single website. Even if the log files collected by these separate servers are compatible, a very interesting problem arises in synchronizing the log files after the fact. Remember that a busy web server may be processing hundreds of page events per second. It is unlikely the clocks on separate servers will be in synchrony to one-hundredth of a second.

You also obtain clickstream data from different parties. Besides your own log files, you may get clickstream data from referring partners or from internet service providers (ISPs). Another important form of clickstream data is the search specification given to a search engine that then directs the visitor to the website.

Finally, if you are an ISP providing web access to directly connected customers, you have a unique perspective because you see every click of your captive customers that may allow more powerful and invasive analyses of the customer's sessions.

The most basic form of clickstream data from a normal website is stateless. That is, the log shows an isolated page retrieval event but does not provide a clear tie to other page events elsewhere in the log. Without some kind of contextual help, it is difficult or impossible to reliably identify a complete visitor session.

The other big frustration with basic clickstream data is the anonymity of the session. Unless visitors agree to reveal their identity in some way, you often cannot be sure who they are, or if you have ever seen them before. In certain situations, you may not distinguish the clicks of two visitors who are simultaneously browsing the website.

Clickstream Data Challenges

Clickstream data contains many ambiguities. Identifying visitor origins, visitor sessions, and visitor identities is something of an interpretive art. Browser caches and proxy servers make these identifications more challenging.

Identifying the Visitor Origin

If you are very lucky, your site is the default home page for the visitor's browser. Every time he opens his browser, your home page is the first thing he sees. This is pretty unlikely unless you are the webmaster for a portal site or an intranet home page, but many sites have buttons which, when clicked, prompt visitors to set their URL as the browser's home page. Unfortunately there is no easy way to determine from a log whether your site is set as a browser's home page.

A visitor may be directed to your site from a search at a portal such as Yahoo! or Google. Such referrals can come either from the portal's index, for which you may have paid a placement fee, or from a word or content search.

For some websites, the most common source of visitors is from a browser bookmark. For this to happen, the visitor must have previously bookmarked your site, and this can occur only after the site's interest and trust levels cross the visitor's bookmark threshold.

Finally, your site may be reached as a result of a clickthrough—a deliberate click on a text or graphical link from another site. This may be a paid-for referral via a banner ad, or a free referral from an individual or cooperating site. In the case of clickthroughs, the referring site will almost always be identifiable as a field in the web event record. Capturing this crucial clickstream data is important to verify the efficacy of marketing programs. It also provides crucial data for auditing invoices you may receive from clickthrough advertising charges.

Identifying the Session

Most web-centric analyses require every visitor session (visit) to have its own unique identity tag, similar to a supermarket receipt number. This is the session ID. Records for every individual visitor action in a session, whether they are derived from the clickstream or an application interaction, must contain this tag. But keep in mind the operational application, such as an order entry system generates this session ID, not the web server.

The basic protocol for the web, Hyper Text Transfer Protocol (HTTP) is stateless; that is, it lacks the concept of a session. There are no intrinsic login or logout actions built into the HTTP protocol, so session identity must be established in some other way. There are several ways to do this:

1. In many cases, the individual hits comprising a session can be consolidated by collating time-contiguous log entries from the same host (IP address). If the log contains a number of entries with the same host ID in a short period of time (for example, one hour), you can reasonably assume the entries are for the same session. This method breaks down for websites with large numbers of visitors because dynamically assigned IP addresses may be reused immediately by different visitors over a brief time period. Also, different IP addresses may be used within the same session for the same visitor. This approach also presents problems when dealing with browsers that are behind some firewalls. Notwithstanding these problems, many commercial log analysis products use this method of session tracking, and it requires no cookies or special web server features.
2. Another much more satisfactory method is to let the web browser place a session-level cookie into the visitor's web browser. This cookie will last as long as the browser is open and in general won't be available in subsequent

browser sessions. The cookie value can serve as a temporary session ID not only to the browser, but also to any application that requests the session cookie from the browser. But using a transient cookie has the disadvantage that you can't tell when the visitor returns to the site at a later time in a new session.

3. HTTP's secure sockets layer (SSL) offers an opportunity to track a visitor session because it may include a login action by the visitor and the exchange of encryption keys. The downside to using this method is that to track the session, the entire information exchange needs to be in high-overhead SSL, and the visitor may be put off by security advisories that can pop up using certain browsers. Also, each host must have its own unique security certificate.
4. If page generation is dynamic, you can try to maintain visitor state by placing a session ID in a hidden field of each page returned to the visitor. This session ID can be returned to the web server as a query string appended to a subsequent URL. This method of session tracking requires a great deal of control over the website's page generation methods to ensure the thread of a session ID is not broken. If the visitor clicks links that don't support this session ID ping-pong, a single session may appear to be multiple sessions. This approach also breaks down if multiple vendors supply content in a single session unless those vendors are closely collaborating.
5. Finally, the website may establish a persistent cookie in the visitor's machine that is not deleted by the browser when the session ends. Of course, it's possible the visitor will have his browser set to refuse cookies, or may manually clean out his cookie file, so there is no absolute guarantee that even a persistent cookie will survive. Although any given cookie can be read only by the website that caused it to be created, certain groups of websites can agree to store a common ID tag that would let these sites combine their separate notions of a visitor session into a "super session."

In summary, the most reliable method of session tracking from web server log records is obtained by setting a persistent cookie in the visitor's browser. Less reliable, but good results can be obtained by setting a session level and a nonpersistent cookie and by associating time-contiguous log entries from the same host. The latter method requires a robust algorithm in the log postprocessor to ensure satisfactory results and to decide when not to take the results seriously.

Identifying the Visitor

Identifying a specific visitor who logs into your site presents some of the most challenging problems facing a site designer, webmaster, or manager of the web analytics group.

- Web visitors want to be anonymous. They may have no reason to trust you, the internet, or their computer with personal identification or credit card information.
- If you request visitors' identity, they may not provide accurate information.
- You can't be sure which family member is visiting your site. If you obtain an identity by association, for instance from a persistent cookie left during a previous visit, the identification is only for the computer, not for the specific visitor. Any family member or company employee may have been using that particular computer at that moment in time.
- You can't assume an individual is always at the same computer. Server-provided cookies identify a computer, not an individual. If someone accesses the same website from an office computer, home computer, and mobile device, a different website cookie is probably put into each machine.

Clickstream Dimensional Models

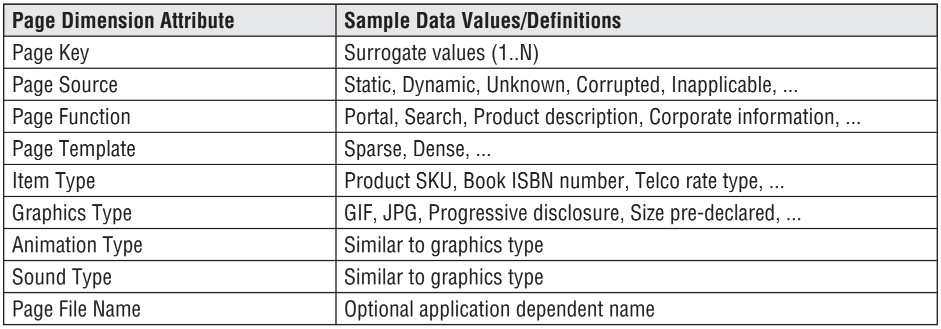
Before designing clickstream dimensional models, let's consider all the dimensions that may have relevance in a clickstream environment. Any single dimensional model will not use all the dimensions at once, but it is nice to have a portfolio of dimensions waiting to be used. The list of dimensions for a web retailer could include:

- Date
- Time of day
- Part
- Vendor
- Status
- Carrier
- Facilities location
- Product
- Customer
- Media
- Promotion
- Internal organization
- Employee
- **Page**
- **Event**
- **Session**
- **Referral**

All the dimensions in the list, except for the last four shown in bold, are familiar dimensions, most of which we have already used in earlier chapters of this book. But the last four are the unique dimensions of the clickstream and warrant some careful attention.

Page Dimension

The *page dimension* describes the page context for a web page event, as illustrated in Figure 15-1. The grain of this dimension is the individual page. The definition of page must be flexible enough to handle the evolution of web pages from static page delivery to highly dynamic page delivery in which the exact page the customer sees is unique at that instant in time. We assume even in the case of the dynamic page that there is a well-defined function that characterizes the page, and we will use that to describe the page. We will not create a page row for every instance of a dynamic page because that would yield a dimension with an astronomical number of rows. These rows also would not differ in interesting ways. You want a row in this dimension for each interesting distinguishable type of page. Static pages probably get their own row, but dynamic pages would be grouped by similar function and type.



Page Dimension Attribute	Sample Data Values/Definitions
Page Key	Surrogate values (1..N)
Page Source	Static, Dynamic, Unknown, Corrupted, Inapplicable, ...
Page Function	Portal, Search, Product description, Corporate information, ...
Page Template	Sparse, Dense, ...
Item Type	Product SKU, Book ISBN number, Telco rate type, ...
Graphics Type	GIF, JPG, Progressive disclosure, Size pre-declared, ...
Animation Type	Similar to graphics type
Sound Type	Similar to graphics type
Page File Name	Optional application dependent name

Figure 15-1: Page dimension attributes and sample data values.

When the definition of a static page changes because it is altered by the webmaster, the page dimension row can either be type 1 overwritten or treated with an alternative slowly changing technique. This decision is a matter of policy for the data warehouse and depends on whether the old and new descriptions of the page differ materially, and whether the old definition should be kept for historical analysis purposes.

Website designers, data governance representatives from the business, and the DW/BI architects need to collaborate to assign descriptive codes and attributes to each page served by the web server, whether the page is dynamic or static. Ideally, the web page developers supply descriptive codes and attributes with each page they create and embed these codes and attributes into the optional fields of the web log files. This crucial step is at the foundation of the implementation of this page dimension.

Before leaving the page dimension, we want to point out that some internet companies track the more granular individual elements on each page of their web sites, including graphical elements and links. Each element generates its own row for each visitor for each page request. A single complex web page can generate hundreds of rows each time the page is served to a visitor. Obviously, this extreme granularity generates astronomical amounts of data, often exceeding 10 terabytes per day!

Similarly, gaming companies may generate a row for every gesture made by every online game player, which again can result in hundreds of millions of rows per day. In both cases, the most atomic fact table will have extra dimensions describing the graphical element, link, or game situation.

Event Dimension

The event dimension describes what happened on a particular page at a particular point in time. The main interesting events are Open Page, Refresh Page, Click Link, and Enter Data. You want to capture that information in this small event dimension, as illustrated in Figure 15-2.

Event Dimension Attribute	Sample Data Values/Definitions
Event Key	Surrogate values (1..N)
Event Type	Open page, Refresh page, Click link, Unknown, Inapplicable
Event Content	Application-dependent fields eventually driven by XML tags

Figure 15-2: Event dimension attributes and sample data values.

Session Dimension

The session dimension provides one or more levels of diagnosis for the visitor's session as a whole, as shown in Figure 15-3. For example, the local context of the session might be Requesting Product Information, but the overall session context might be Ordering a Product. The success status would diagnose whether the mission was completed. The local context may be decidable from just the identity of the current page, but the overall session context probably can be judged only by processing the visitor's complete session at data extract time. The customer status attribute is a convenient place to label the customer for periods of time, with labels that are not clear either from the page or immediate session. These statuses may be derived from auxiliary business processes in the DW/BI system, but by placing these labels deep within the clickstream, you can directly study the behavior of certain types of customers. Do not put these labels in the customer dimension because they may change over very short periods of time. If there are a large number of these statuses, consider creating a separate customer status mini-dimension rather than embedding this information in the session dimension.

Session Dimension Attribute	Sample Data Values/Definitions
Session Key	Surrogate values (1..N)
Session Type	Classified, Unclassified, Corrupted, Inapplicable
Local Context	Page-derived context like Requesting Product Information
Session Context	Trajectory-derived context like Ordering a Product
Action Sequence	Summary label for overall sequence of actions during session
Success Status	Identifies whether overall session mission was accomplished
Customer Status	New customer, High value customer, About to cancel, In default

Figure 15-3: Session dimension attributes and sample data values.

This dimension groups sessions for analysis, such as:

- How many customers consulted your product information before ordering?
- How many customers looked at your product information and never ordered?
- How many customers did not finish ordering? Where did they stop?

Referral Dimension

The referral dimension, illustrated in Figure 15-4, describes how the customer arrived at the current page. The web server logs usually provide this information. The URL of the previous page is identified, and in some cases additional information is present. If the referrer was a search engine, usually the search string is specified. It may not be worthwhile to put the raw search specification into your database because the search specifications are so complicated and idiosyncratic that an analyst may not be able to query them usefully. You can assume some kind of simplified and cleaned specification is placed in the specification attribute.

Referral Dimension Attribute	Sample Data Values/Definitions
Referral Key	Surrogate values (1..N)
Referral Type	Intra site, Remote site, Search engine, Corrupted, Inapplicable
Referring URL	www.organization-site.com/linkspage
Referring Site	www.organization-site.com
Referring Domain	www.organization-site.com
Search Type	Simple text match, Complex logical match
Specification	Actual spec used (useful if simple text, otherwise questionable)
Target	Meta tags, Body text, Title (where search found its match)

Figure 15-4: Referral dimension attributes and sample data values.

Clickstream Session Fact Table

Now that you have a portfolio of useful clickstream dimensions, you can design the primary clickstream dimensional models based on the web server log data. This business process can then be integrated into the family of other web retailing subject areas.

With an eye toward keeping the first fact table from growing astronomically, you should choose the grain to be one row for each completed customer session. This grain is significantly higher than the underlying web server logs which record each individual page event, including individual pages as well as each graphical element on each page. While we typically encourage designers to start with the most granular data available in the source system, this is a purposeful deviation from our standard practices. Perhaps you have a big site recording more than 100 million page fetches per day, and 1 billion micro page events (graphical elements), but you want to start with a more manageable number of rows to be loaded each day. We assume for the sake of argument that the 100 million page fetches boil down to 20 million complete visitor sessions. This could arise if an average visitor session touched 5 pages.

The dimensions that are appropriate for this first fact table are calendar date, time of day, customer, page, session, and referrer. Finally, you can add a set of measured facts for this session including session seconds, pages visited, orders placed, units ordered, and order dollars. The completed design is shown in Figure 15-5.

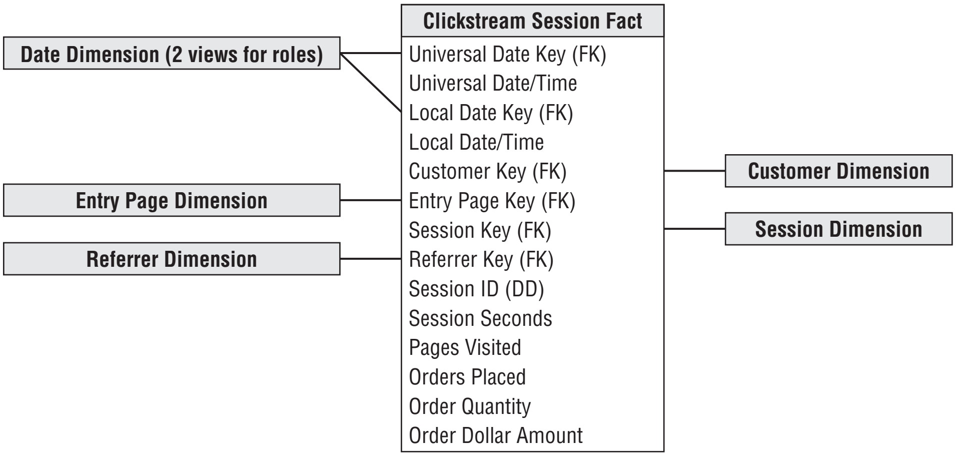


Figure 15-5: Clickstream fact table design for complete sessions.

There are a number of interesting aspects to this design. You may wonder why there are two connections from the calendar date dimension to the fact table and two date/time stamps. This is a case in which both the calendar date and the time of day must play two different roles. Because you are interested in measuring the precise times of sessions, you must meet two conflicting requirements. First, you want to make sure you can synchronize all session dates and times internationally across multiple time zones. Perhaps you have other date and time stamps from other web servers or nonweb systems elsewhere in the DW/BI environment. To achieve true synchronization of events across multiple servers and processes, you must record all session dates and times, uniformly, in a single time zone such as Greenwich Mean Time (GMT) or Coordinated Universal Time (UTC). You should interpret the session date and time combinations as the beginning of the session. Because you have the dwell time of the session as a numeric fact, you can tell when the session ended, if that is of interest.

The other requirement you meet with this design is to record the date and time of the session relative to the visitor's wall clock. The best way to represent this information is with a second calendar date foreign key and date/time stamp. Theoretically, you could represent the time zone of the customer in the customer dimension table, but constraints to determine the correct wall clock time would be horrendously complicated. The time difference between two cities (such as London and Sydney) can change by as much as two hours at different times of the year depending on when these cities go on and off daylight savings time. This is not the business of the BI reporting application to work out. It is the business of the database to store this information, so it can be constrained in a simple and direct way.

The two role-playing calendar date dimension tables are views on a single underlying table. The column names are massaged in the view definition, so they are slightly different when they show up in the user interface pick lists of BI tools. Note that the use of views makes the two instances of each table semantically independent.

We modeled the exact instant in time with a full date/time stamp rather than a time-of-day dimension. Unlike the calendar date dimension, a time-of-day dimension would contain few if any meaningful attributes. You don't have labels for each hour, minute, or second. Such a time-of-day dimension could be ridiculously large if its grain were the individual second or millisecond. Also, the use of an explicit date/time stamp allows direct arithmetic between different date/time stamps to calculate precise time gaps between sessions, even those crossing days. Calculating time gaps using a time-of-day dimension would be awkward.

The inclusion of the page dimension in Figure 15-5 may seem surprising given the grain of the design is the customer session. However, in a given session, a very interesting page is the entry page. The page dimension in this design is the page the session started with. In other words, how did the customer hop onto your bus just now? Coupled with the referrer dimension, you now have an interesting ability to analyze how and why the customer accessed your website. A more elaborate design would also add an exit page dimension.

You may be tempted to add the causal dimension to this design, but if the causal dimension focuses on individual products, it would be inappropriate to add it to this design. The symptom that the causal dimension does not mesh with this design is the multivalued nature of the causal factors for a given complete session. If you run ad campaigns or special deals for several products, how do you represent this multivalued situation if the customer's session involves several products? The right place for a product-oriented causal dimension will be in the more fine-grained table described in the next fact table example. Conversely, a more broadly focused market conditions dimension that describes conditions affecting all products would be appropriate for a session-grained fact table.

The session seconds fact is the total number of seconds the customer spent on the site during this session. There will be many cases in which you can't tell when the customer left. Perhaps the customer typed in a new URL. This won't be detected by conventional web server logs. (If the data is collected by an ISP who can see every click across sessions, this particular issue goes away.) Or perhaps the customer got up out of the chair and didn't return for 1 hour. Or perhaps the customer just closed the browser without making any more clicks. In all these cases, your extract software needs to assign a small and nominal number of seconds to this last session step, so the analysis is not unrealistically distorted.

We purposely designed this first clickstream fact table to focus on complete visitor sessions while keeping the size under control. The next schema drops down to the lowest practical granularity you can support in the data warehouse: the individual page event.

Clickstream Page Event Fact Table

The granularity of the second clickstream fact table is the individual page event in each customer session; the underlying micro events recording graphical elements such as JPGs and GIFs are discarded (unless you are Yahoo! or eBay as described previously). With simple static HTML pages, you can record only one interesting event per page view, namely the page view. As websites employ dynamically created XML-based pages, with the ability to establish an on-going dialogue through the page, the number and type of events will grow.

This fact table could become astronomical in size. You should resist the urge to aggregate the table up to a coarser granularity because that inevitably involves dropping dimensions. Actually, the first clickstream fact table represents just such an aggregation; although it is a worthwhile fact table, analysts cannot ask questions about visitor behavior or individual pages.

Having chosen the grain, you can choose the appropriate dimensions. The list of dimensions includes calendar date, time of day, customer, page, event, session, session ID, step (three roles), product, referrer, and promotion. The completed design is shown in Figure 15-6.

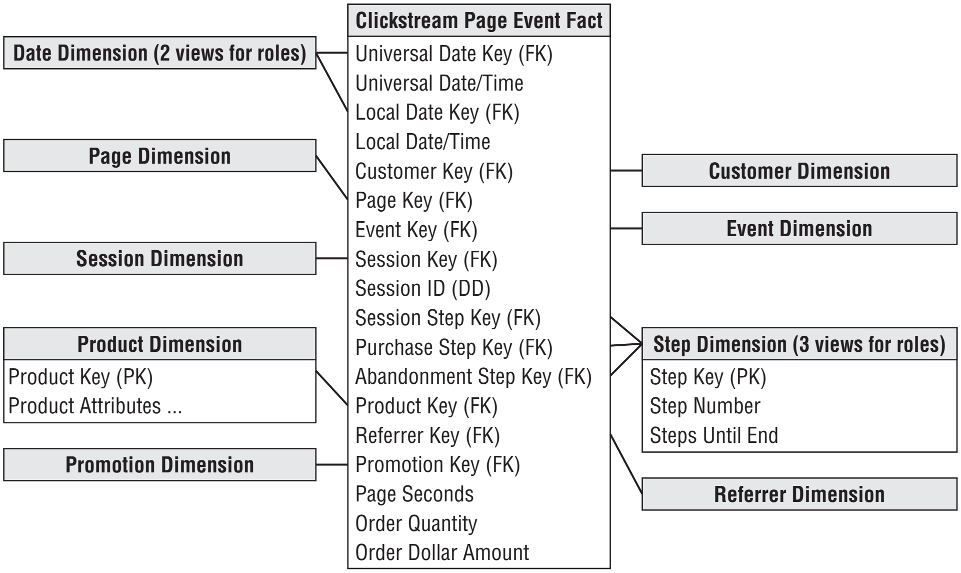


Figure 15-6: Clickstream fact table design for individual page use.

Figure 15-6 looks similar to the first design, except for the addition of the page, event, promotion, and step dimensions. This similarity between fact tables is typical of dimensional models. One of the charms of dimensional modeling is the “boring” similarity of the designs. But that is where they get their power. When the designs have a predictable structure, all the software up and down the DW/BI chain, from extraction, to database querying, to the BI tools, can exploit this similarity to great advantage.

The two roles played by the calendar date and date/time stamps have the same interpretation as in the first design. One role is the universal synchronized time, and the other role is the local wall clock time as measured by the customer. In this fact table, these dates and times refer to the individual page event.

The page dimension refers to the individual page. This is the main difference in grain between the two clickstream fact tables. In this fact table you can see all the pages accessed by the customers.

As described earlier, the session dimension describes the outcome of the session. A companion column, the session ID, is a degenerate dimension that does not have a join to a dimension table. This degenerate dimension is a typical dimensional modeling construct. The session ID is simply a unique identifier, with no semantic content, that serves to group together the page events of each customer session in an unambiguous way. You did not need a session ID degenerate dimension in the first fact table, but it is included as a “parent key” if you want to easily link to the individual page event fact table. We recommend the session dimension be at a higher level of granularity than the session ID; the session dimension is intended to describe classes and categories of sessions, not the characteristics of each individual session.

A product dimension is shown in this design under the assumption this website belongs to a web retailer. A financial services site probably would have a similar dimension. A consulting services site would have a service dimension. An auction site would have a subject or category dimension describing the nature of the items being auctioned. A news site would have a subject dimension, although with different content than an auction site.

You should accompany the product dimension with a promotion dimension so you can attach useful causal interpretations to the changes in demand observed for certain products.

For each page event, you should record the number of seconds that elapse before the next page event. Call this page seconds to contrast it with session seconds in the first fact table. This is a simple example of paying attention to conformed facts. If you call both of these measures simply “seconds,” you risk having these seconds inappropriately added or combined. Because these seconds are not precisely equivalent, you should name them differently as a warning. In this particular case, you would expect the page seconds for a session in this second fact table to add up to the session seconds in the first fact table.

The final facts are units ordered and order dollars. These columns will be zero or null for many rows in this fact table if the specific page event is not the event that places the order. Nevertheless, it is highly attractive to provide these columns because they tie the all-important web revenue directly to behavior. If the units ordered and order dollars were only available through the production order entry system elsewhere in the DW/BI environment, it would be inefficient to perform the revenue-to-behavior analysis across multiple large tables. In many database management systems, these null facts are handled efficiently and may take up literally zero space in the fact table.

Step Dimension

Because the fact table grain is the individual page event, you can add the powerful step dimension described in Chapter 8: Customer Relationship Management. The step dimension, originally shown in Figure 8-11, provides the position of the specific page event within the overall session.

The step dimension becomes particularly powerful when it is attached to the fact table in various roles. Figure 15-6 shows three roles: overall session, purchase subsession, and abandonment subsession. A purchase subsession, by definition, ends in a successful purchase. An abandonment subsession is one that fails to complete a purchase transaction for some reason. Using these roles of the step dimension allows some very interesting queries. For example, if the purchase step dimension is constrained to step number 1, the query returns nothing but the starting page for successful purchase experiences. Conversely, if the abandonment step dimension is constrained to zero steps remaining, the query returns nothing but the last and presumably most unfulfilling pages visited in unsuccessful purchase sessions. Although the whole design shown in Figure 15-6 is aimed at product purchases, the step dimension technique can be used in the analysis of any sequential process.

Aggregate Clickstream Fact Tables

Both clickstream fact tables designed thus far are pretty large. There are many business questions that would be forced to summarize millions of rows from these tables. For example, if you want to track the total visits and revenue from major demographic groups of customers accessing your website on a month-by-month basis, you can certainly do that with either fact table. In the session-grained fact table, you would constrain the calendar date dimension to the appropriate time span (say January, February, and March of the current year). You would then create row headers from the demographics type attribute in the customer dimension and the month attribute in the calendar dimension (to separately label the three months in the output). Finally, you would sum the Order Dollars and count the number of sessions. This all works fine. But it is likely to be slow without help from an aggregate table. If this kind of query is frequent, the DBA will be encouraged to build an aggregate table, as shown in Figure 15-7.

You can build this table directly from your first fact table, whose grain is the individual session. To build this aggregate table, you group by month, demographic type, entry page, and session outcome. You count the number of sessions, and sum all the other additive facts. This results in a drastically smaller fact table, almost certainly less than 1% of the original session-grained fact table. This reduction in size translates directly to a corresponding increase in performance for most queries. In other words, you can expect queries directed to this aggregate table to run at least 100 times as fast.

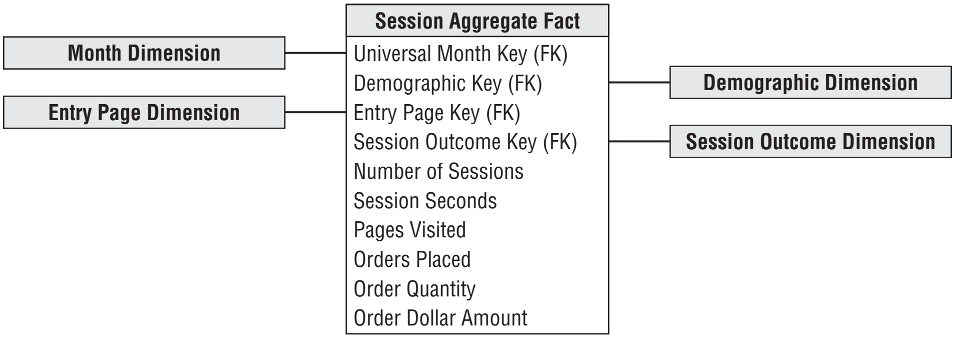


Figure 15-7: Aggregate clickstream fact table.

Although it may not have been obvious, we followed a careful discipline in building the aggregate table. This aggregate fact table is connected to a set of shrunken rollup dimensions directly related to the original dimensions in the more granular fact tables. The month dimension is a conformed subset of the calendar day dimension's attributes. The demographic dimension is a conformed subset of customer dimension attributes. You should assume the page and session tables are unchanged; a careful design of the aggregation logic could suggest a conformed shrinking of these tables as well.

Google Analytics

Google Analytics (GA) is a service provided by Google that is best described as an external data warehouse that provides many insights about how your website is used. To use GA, you modify each page of your website to include a GA tracking code (GATC) embedded in a Java code snippet located in the HTML `<head>` declaration of each page to be tracked. When a visitor accesses the page, information is sent to the Analytics service at Google, as long as the visitor has JavaScript enabled. Virtually all of the information described in this chapter can be collected through GA, with the exception of personally identifiable information (PII) which is forbidden by GA's terms of service. GA can be combined with Google's Adword service to track ad campaigns and conversions (sales). Reportedly, GA is used by more than 50% of the most popular web sites on the internet.

Data from GA can be viewed in a BI tool dashboard online directly from the underlying GA databases, or data can be delivered to you in a wide variety of standard and custom reports, making it possible to build your own local business process schema surrounding this data.

Interestingly, GA's detailed technical explanation of the data elements that can be collected through the service are described correctly as either dimensions or measures. Someone at Google has been reading our books…

Integrating Clickstream into Web Retailer's Bus Matrix

This section considers the business processes needed by a web-based computer retailer. The retailer's enterprise data warehouse bus matrix is illustrated in Figure 15-8. Note the matrix lists business process subject areas, not individual fact tables. Typically, each matrix row results in a suite of closely associated fact tables and/or OLAP cubes, which all represent a particular business process.

The Figure 15-8 matrix has a number of striking characteristics. There are a lot of check marks. Some of the dimensions, such as date/time, organization, and employee appear in almost every business process. The product and customer dimensions dominate the middle part of the matrix, where they are attached to business processes that describe customer-oriented activities. At the top of the matrix, suppliers and parts dominate the processes of acquiring the parts that make up products and building them to order for the customer. At the bottom of the matrix, you have classic infrastructure and cost driver business processes that are not directly tied to customer behavior.

The web visitor clickstream subject area sits squarely among the customer-oriented processes. It shares the date/time, product, customer, media, causal, and service policy dimensions with several other business processes nearby. In this sense it should be obvious that the web visitor clickstream data is well integrated into the fabric of the overall DW/BI system for this retailer. Applications tying the web visitor clickstream will be easy to integrate across all the processes sharing these conformed dimensions because separate queries to each fact table can be combined across individual rows of the report.

The web visitor clickstream business process contains the four special clickstream dimensions not found in the others. These dimensions do not pose a problem for applications. Instead, the ability of the web visitor clickstream data to bridge between the web world and the brick-and-mortar world is exactly the advantage you are looking for. You can constrain and group on attributes from the four web dimensions and explore the effect on the other business processes. For example, you can see what kinds of web experiences produce customers who purchase certain kinds of service policies and then invoke certain levels of service demands.

	Date and Time	Part	Vendor	Carrier	Facility	Product	Customer	Media	Promotion	Service Policy	Internal Organization	Employee	Clickstream (4 dims)
Supply Chain Management													
Supplier Purchase Orders	X	X	X		X						X	X	
Supplier Deliveries	X	X	X	X	X						X		
Part Inventories	X	X	X		X						X		
Product Assembly Bill of Materials	X	X	X		X	X					X	X	
Product Assembly to Order	X	X	X		X	X	X				X	X	
Customer Relationship Management													
Product Promotions	X					X	X	X	X		X		
Advertising	X					X		X	X		X		
Customer Communications	X					X	X				X	X	
Customer Inquiries	X				X	X	X		X	X	X	X	
Web Visitor Clickstream	**X**					**X**	**X**	**X**	**X**	**X**			**X**
Product Orders	X					X	X		X			X	
Service Policy Orders	X					X	X		X	X	X	X	
Product Shipments	X			X	X	X	X			X	X	X	
Customer Billing	X					X	X			X	X	X	
Customer Payments	X						X				X	X	
Product Returns	X				X	X	X			X	X	X	
Product Support	X				X	X	X			X	X	X	
Service Policy Responses	X				X	X	X			X	X	X	
Operations													
Employee Labor	X				X						X	X	
Human Resources	X				X						X	X	
Facilities Operations	X				X						X	X	
Web Site Operations	X				X						X	X	

Figure 15-8: Bus matrix for web retailer.

Finally, it should be pointed out that the matrix serves as a kind of communications vehicle for all the business teams and senior management to appreciate the need to conform dimensions and facts. A given column in the matrix is, in effect, an invitation list to the meeting for conforming the dimension!

Profitability Across Channels Including Web

After the DW/BI team successfully implements the initial clickstream fact tables and ties them to the sales transaction and customer communication business processes, the team may be ready to tackle the most challenging subject area of all: web profitability.

You can tackle web profitability as an extension of the sales transaction process. Fundamentally, you are allocating all the activity and infrastructure costs down to each sales transaction. You could, as an alternative, try to build web profitability on top of the clickstream, but this would involve an even more controversial allocation process in which you allocate costs down to each session. It would be hard to assign activity and infrastructure costs to a session that has no obvious product involvement and leads to no immediate sale.

A big benefit of extending the sales transaction fact table is that you get a view of profitability across all your sales channels, not just the web. In a way, this should be obvious because you know that you must sort out the costs and assign them to the various channels.

The grain of the profit and loss facts is each individual line item sold on a sales ticket to a customer at a point in time, whether it's a single sales ticket or single web purchasing session. This is the same as the grain of the sales transaction business process and includes all channels, assumed to be store sales, telesales, and web sales.

The dimensions of the profit and loss facts are also the same as the sales transaction fact table: date, time, customer, channel, product, promotion, and ticket number (degenerate). The big difference between the profitability and sales transaction fact tables is the breakdown of the costs, as illustrated in Figure 15-9.

Before discussing the allocation of costs, let us examine the format of the profit and loss facts. It is organized as a simple profit and loss (P&L) statement (refer to Figure 6-14). The first fact is familiar units sold. All the other facts are dollar values beginning with the value of the sale as if it were sold at the list or catalog price, referred to as gross revenue. Assuming sales often take place at lower prices, you would account for any difference with a manufacturer's allowance, marketing promotion that is a price reduction, or markdown done to move the inventory. When these effects are taken into account, you can calculate the net revenue, which is the true net price the customer pays times the number of units purchased.

The rest of the P&L consists of a series of subtractions, where you calculate progressively more far-reaching versions of profit. You can begin by subtracting the product manufacturing cost if you manufacture it, or equivalently, the product acquisition cost if it is acquired from a supplier. Then subtract the product storage cost. At this point, many enterprises call this partial result the gross profit. You can divide this gross profit by the gross revenue to get the gross margin ratio.

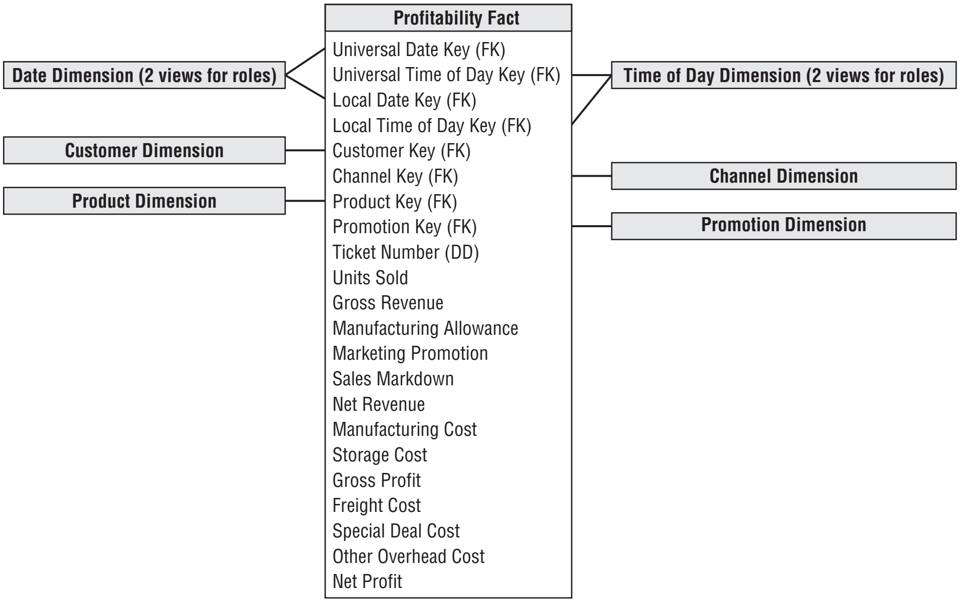


Figure 15-9: Profit and loss facts across sales channels, including web sales.

Obviously, the columns called net revenue and gross profit are calculated directly from the columns immediately preceding them in the fact table. But should you explicitly store these columns in the database? The answer depends on whether you provide access to this fact table through a view or whether users or BI applications directly access the physical fact table. The structure of the P&L is sufficiently complex that, as the data warehouse provider, you don't want to risk the important measures like net revenue and gross profit being computed incorrectly. If you provide all access through views, you can easily provide the computed columns without physically storing them. But if your users are allowed to access the underlying physical table, you should include net revenue, gross profit, and net profit as physical columns.

Below the gross profit you can continue subtracting various costs. Typically, the DW/BI team must separately source or estimate each of these costs. Remember the actual entries in any given fact table row are the fractions of these total costs allocated all the way down to the individual fact row grain. Often there is significant pressure on the DW/BI team to deliver the profitability business process. Or to put it another way, there is tremendous pressure to source all these costs. But how good are the costs in the various underlying data sets? Sometimes a cost is only available as a national average, computed for an entire year. Any allocation scheme is going to assign a kind of pro forma value that has no real texture to it. Other costs will be broken down a little more granularly, perhaps to calendar quarter and by geographic region (if relevant). Finally, some costs may be truly activity-based and vary in a highly dynamic, responsive, and realistic way over time.

Website system costs are an important cost driver in electronic commerce businesses. Although website costs are classic infrastructure costs, and are therefore difficult to allocate directly to the product and customer activity, this is a key step in developing a web-oriented P&L statement. Various allocation schemes are possible, including allocating the website costs to various product lines by the number of pages devoted to each product, allocating the costs by pages visited, or allocating the costs by actual web-based purchases.

The DW/BI team cannot be responsible for implementing activity-based costing (ABC) in a large organization. When the team is building a profitability dimensional model, the team gets the best cost data available at the moment and publishes the P&L. Perhaps some of the numbers are simple rule-of-thumb ratios. Others may be highly detailed activity-based costs. Over time, as the sources of cost improve, the DW/BI team incorporates these new sources and notifies the users that the business rules have improved.

Before leaving this design, it is worthwhile putting it in perspective. When a P&L structure is embedded in a rich dimensional framework, you have immense power. You can break down all the components of revenue, cost, and profit for every conceivable slice and dice provided by the dimensions. You can answer what is profitable, but also answer "why" because you can see all the components of the P&L, including:

- How profitable is each channel (web sales, telesales, and store sales)? Why?
- How profitable are your customer segments? Why?
- How profitable is each product line? Why?
- How profitable are your promotions? Why?
- When is your business most profitable? Why?

The symmetric dimensional approach enables you to combine constraints from many dimensions, allowing compound versions of the profitability analyses like:

- Who are the profitable customers in each channel? Why?
- Which promotions work well on the web but do not work well in other channels? Why?

Summary

The web retailer case study used in this chapter is illustrative of any business with a significant web presence. Besides tackling the clickstream subject area at multiple levels of granularity, the central challenge is effectively integrating the clickstream data into the rest of the business. We discussed ways to address the identification challenges associated with the web visitor, their origin, and session boundaries, along with the special dimensions unique to clickstream data, including the session, page, and step dimensions.

In the next chapter, we'll turn our attention to the primary business processes in an insurance company as we recap many of the dimensional modeling patterns presented throughout this book.