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The more things change

Value creation, value capture, and the Internet of Things

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Most "things," from alarm clocks to Zambonis, the human body included, have long operated largely "dark," with their location, position, and functional state unknown or even unknowable. No longer, thanks to the Internet of Things (IoT), a suite of technologies and associated business processes that allow us to track and count, observe and identify, evaluate and act in circumstances heretofore effectively invisible and beyond reach.

In relaxing many of the constraints that have traditionally defined fundamental business processes, the IoT demands that we revisit the two defining questions of strategy: how to create value, and how to capture it.

We have concluded that how companies create value has changed profoundly. A tennis player no longer values her racquet solely in terms of the stiffness of the frame, the string tension, and its weight and balance, but also—in the case of Babolat's Play and Connect racquet—as a source of information about her tennis stroke and how to improve it.[1] In other words, it is not merely the features of a product or service that create differentiated value—it is *information* about that product or service. And information, we argue, creates value very differently than do products or services.

How companies capture value remains largely the same, a function of competitive position and competitive advantage. Companies that control the flow of information in the value creation process enjoy competitive positions that are likelier to afford better opportunities to capture value from other participants in their ecosystem. In other words, they know where to play. Companies that differentiate the way in which they control the flow of information from other companies with similar positions enjoy a competitive advantage. In other words, they know how to win.

IoT technology is creating opportunities in unexpected places and ways, including Internet-connected wearable fitness monitors, insurance policies, pill bottles

that know when you've opened them, retail supply chains, and, yes, tennis racquets. We hope you will agree that embracing the new challenges of information-based value creation without abandoning the time-tested tools of value capture—where to play, and how to win—is a powerful first step in creating an effective IoT strategy for your organization.

WHAT'S NEW: VALUE CREATION

Putting a sensor in a tennis racquet can let you know that your overhead smash is off-center. This knowledge helps relatively little, however, if you cannot act in ways that advance desired outcomes—in this case, improving your game. In other words, information creates value only when it is used to modify future action in beneficial ways. Ideally, this modified action gives rise to new information, allowing the learning process to continue. Information, then, creates value not in a linear value chain of process steps but, rather, in a never-ending value loop.

The mere creation of information does not enable its effective use, however, and so we are well-served to capture the stages between action in the world (your overhead smash) and improved action in the world (your better overhead smash). In completing a circuit of the Value Loop, from action back to modified action, information is *communicated* from its location of generation to where it can be processed—perhaps in the case of the tennis racquet, to your smartphone.[2] Information is *aggregated* over time or space in order to create data sets that can be *analyzed* in ways that generate prescriptions for action.[3] After all, data from a single tennis stroke do not provide nearly as much value as data over a one-hour practice session,

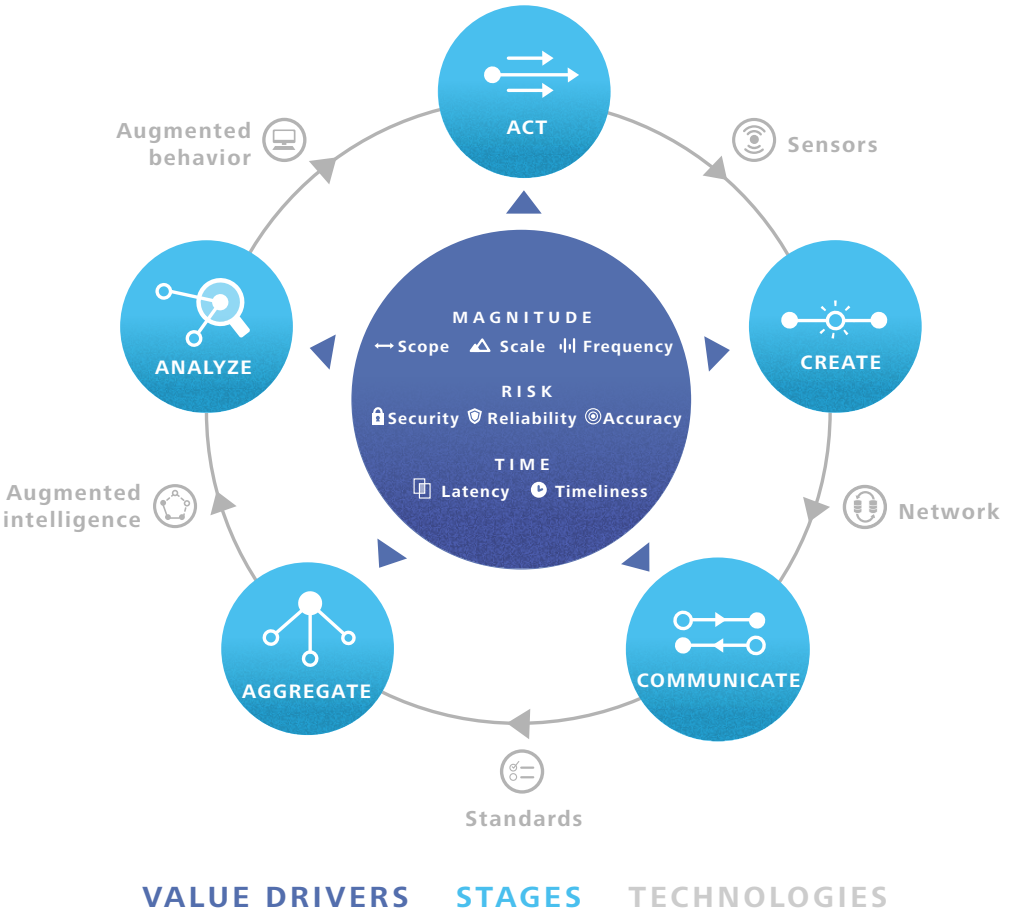
Table 1. The stages of information value creation

Stage	Definition
Create	The use of sensors to generate information about a physical event or state
Communicate	The transmission of information from one place to another
Aggregate	The gathering together of information created at different times or from different sources
Analyze	The discernment of patterns or relationships among phenomena that leads to descriptions, predictions, or prescriptions for action
Act	Initiating, maintaining, or changing a physical event or state

or as much motivation as comparing your stroke with those of relevant peers. These prescriptions guide modifications to your stroke. New action is then sensed, which *creates* new information, starting the cycle anew (see table 1).

We capture the stages (that is, *Create*, *Communicate*, *Aggregate*, *Analyze*, *Act*) through which information passes in order to create value with the Information Value Loop, shown in figure 1.

Figure 1. The Information Value Loop



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The technologies illustrated around the perimeter of the Value Loop have been under development for decades. For example, if you've ever seen the "check engine" light come on in your car and had the requisite repairs done in a timely way, you've benefited from an information value loop. Something about your car's operation—an action—triggered a sensor, which communicated the data to a monitoring

device. These data's significance were determined based on aggregated information and prior analysis, and the light came on, which in turn triggered a trip to the garage and necessary repairs.

In 1991 Mark Weiser, then of Xerox PARC, saw beyond these simple applications. Extrapolating trends in technology, he described "ubiquitous computing," a world in which objects of all kinds could sense, communicate, analyze, and act or react to people and other machines autonomously, in a manner no more intrusive or noteworthy than how we currently turn on a light or open a tap.

The future he imagined is increasingly upon us—not thanks to any one technological advance or even breakthrough but, rather, due to a confluence of improvements to a suite of technologies that collectively have reached levels of performance enabling complete systems relevant to a human-sized world (see table 2).[4] Today's

Table 2. The enabling technologies of the Internet of Things

Stage	Definition	Examples
Sensors	A device that generates an electronic signal from a physical condition or event	The cost of an image sensor has fallen from $22 to 40 cents in the last 20 years. Similar trends have made other types of sensors small, inexpensive, and robust enough to create information on everything from fetal heartbeats via conductive fabric in Mom's clothing to jet engines roaring at 35,000 feet.[5]
Networks	A mechanism for communicating an electronic signal	Wireless networking technologies can deliver bandwidths of 300 megabits per second (Mbps) to 1 gigabit per second (Gbps) with near-ubiquitous coverage.[6]
Standards	Commonly accepted prohibitions or prescriptions for action	Technical standards for interoperability are emerging via a number of mechanisms, including industry consortia and legal or regulatory mandates.
Augmented intelligence	Analytical tools that improve the ability to describe, predict, and exploit relationships among phenomena	Petabyte-sized (10^15 bytes, or 1,000 TB) databases can now be searched and analyzed, even when populated with unstructured (e.g., text or video) data sets.[7] Software that learns is giving rise to "artificial intelligence" that might soon substitute for human analysis and judgment in many circumstances.
Augmented behavior	Technologies and techniques that improve compliance with prescribed action	Machine-to-machine interfaces are replacing reliably fallible human intervention with automated optimized processes. Insights into human cognitive biases are making prescriptions for action based on augmented intelligence more effective and reliable.[8]

IoT applications, in what is now known as automotive telematics, have the potential to go far beyond "check engine." Companies such as Delphi offer aftermarket solutions for vehicle diagnostics and maintenance, but some smart automobiles now drive off the showroom floor with remote diagnostics and system monitoring capabilities pre-installed. Sensors in the vehicles monitor the functionality of various mechanical and electrical systems, creating information about the vehicle's status. That information can then be communicated to the dealership and to the driver via console alerts and mobile apps and aggregated to develop a fuller picture of functionality for the driver, dealer, and manufacturer.

Getting information around the Value Loop allows an organization to create value; how much value is created is a function of the "value drivers," which capture the *characteristics* of the information that makes its way around the Value Loop. The first formulation of these drivers to gain general acceptance came in 2001: volume, velocity, and variety.[9] The intuitively appealing argument made then was that more information, generated more quickly, and capturing a wider range of features about the world, would be more valuable. Since then, this alliterative list has grown to include veracity, viability, variability, visualization, and others besides.[10] The limiting factor seems to be the quality of one's thesaurus.

We can bring order to this chaos by recalling that the value of information inheres largely in its flow: from being created through sensing action back to informing more effective action. This implies that information can be valued much as one would value any flow—say, cash. The value of a cash flow is determined by the *magnitude* of cash one expects, the *risk* that it will not materialize as expected, and the *time* over which the cash will arrive.[11] A greater magnitude of money, generated at lower risk, and over a shorter time period all increase the cash flow's value. Similarly, the drivers of information value can be captured perhaps more precisely and sorted into the same categories of magnitude, risk, and time (see table 3).

Different value drivers will have different levels of importance based on the specific value loop in question. For example, in the retail sector, a sales manager wants to be able to influence customer decisions, and that can require knowing what customers want *now* and *here*. This can require information with higher *frequency*, *accuracy*, and *timeliness* so that the retailer can influence customer action in real time through, for example, offering complementary products or incentives. (Having a system in place that anticipates and responds to customers on the spot represents a big step beyond, say, mailing coupons days after a purchase.)

At the same time, an inventory manager might not require real-time updates, since store inventory is not restocked that quickly. Hourly or even less frequent data updates might suffice. Yet scale and scope might well matter much more: Knowing

Table 3. Information value drivers

Value driver	Definition
Magnitude	Factors that determine the amount of information that informs action
Scale	Corresponding to "volume," this is the number of instances of the same action that inform subsequent action. One can dispatch trucks knowing the location of one truck in a fleet or knowing the locations of all the trucks in a fleet.
Scope	Corresponding to "variety," this is the number of different dimensions of an action on which information informs subsequent action. One can dispatch trucks knowing the location of a truck, or knowing that truck's location, speed, and direction.
Frequency	Corresponding to "velocity," this is the interval between opportunities to adapt action based on new information. One can update truck dispatches knowing the truck locations once per hour, or knowing them once per minute.
Risk	Factors that determine the probability that information will create value in the manner expected
Security	Is the information used only by those with the necessary authorization? If thieves also know the location of one's trucks, the information may well lead to a net reduction in value due to higher rates of theft.
Reliability	Is the information consistently generated as expected? If the other value drivers of information are unpredictable, it is more difficult to make optimal use of that information.
Accuracy	Does the information capture the actual value of what it represents? If the information on the location of the truck misrepresents the truck's actual location, dispatch instructions based on that information will be less valuable.
Time	Factors that determine how quickly value can be created from information
Timeliness	Is the information available for use at the most opportune moments? Dispatch schedules that are updated as the trucks reach their routes' halfway point are more valuable than those updated after the trucks have returned to the depot.
Latency	Does the information capture the state of the world as it is, or as it was? Knowing trucks' locations 30 minutes ago is less valuable than knowing their locations 30 seconds ago.

Note: The categories of magnitude, risk, and time are a framework within which one can identify the drivers that are relevant to a given use case. The elements identified above within each category are not intended to be definitive or exhaustive, although, as a practical matter, they are likely a good place to start and, in many cases, will prove sufficient.

Source: Deloitte analysis

the inventory status of every product in every store—and linking that information to warehouses, drivers, and manufacturers also generating real-time data—can enable significant purchasing or logistical efficiencies.

In sum, companies can create value through both the value chain for each of their products or services, which determines performance, and the value loop for each product or service, which determines informational content. Today, few products or services are information-free, and so both typically feature in some measure. Thanks to advances in the enabling technologies of the IoT, the information content of many markets is rising rapidly, and so an increasing number are usefully characterized as information-centric. As information becomes a key differentiator in more and more markets, a command of the Information Value Loop may well become a prerequisite to competitive success.

WHAT'S THE SAME: VALUE CAPTURE

The value loops in each of Babolat's tennis racquet, automotive telematics, and either of our retail applications are relatively self-contained. Consequently, those creating the value would necessarily capture it. Yet many value loops are enabled by ecosystems of independent organizations that must simultaneously cooperate and compete.[12] In these circumstances, companies must pay much closer attention to questions of value capture. This means answering two questions: where to play, and how to win.[13]

Where to play

In any process, there will be a stage that determines the flow rate for the process as a whole; this is known as the *bottleneck* for the process.[14] A bottleneck is characteristically seen as a bad thing, a limiting factor in an otherwise smooth, even flow. Yet in a value loop enabled by an ecosystem, the bottleneck is an opportunity for value capture, precisely because it is what limits value creation. For a given value loop, the flow of information as measured by the value drivers that matter most (magnitude, risk, and/or time) will be at its lowest at one or more of the stages in the loop. The player in the ecosystem that determines the flow rate of information with respect to those drivers at that stage is in a position to increase the value of the entire loop and therefore in a position to capture more than its fair share of that increase.

Take, for example, the problem of patient compliance with medication regimens. At least half of patients are noncompliant in ways that compromise their health and result in significant cost increases for unnecessary care.[15] The US Department of Health and Human Services estimates that the systemic cost of non-adherence runs up to $105 billion annually.[16]

Currently, there is no IoT-enabled value loop because there is no automatically generated data on patient action: People have to log what they take and when. Consequently, the bottleneck has been at the *Create* stage due to the lack of an appropriate application of sensor technology.

David Rose, of the MIT Media Lab, has attempted to tackle this problem with GlowCap, a pill bottle with a "smart" cap that is connected to the Internet.[17] A patient registers a GlowCap bottle, each of which has its own unique identifier, inputting the drug and dosage. In tandem with a reminder light, the bottle cap flashes to prompt a patient to take her medication; reminders escalate to text messages and automated phone calls. The loop is completed when a patient responds to these prompts and removes the GlowCap from the bottle. The patient can use a button on the bottom of the cap to trigger a reorder of the medication.[18] It appears to work: In a study cited by GlowCap, patient compliance increased from 75 percent to over 95 percent as a result of the technology.[19] In effect, GlowCap addresses the bottleneck with … the bottle cap.

The value loop created by GlowCap is potentially far-reaching: The device creates and communicates data and enables the aggregation of data at the level of individual patients. This is of value to patients who value their health. It is valuable to the insurers that pay for their treatment. It is valuable to hospitals looking to reduce their readmission rates.

When a company enjoys the latitude to choose where it plays in a value loop, it should, in general, play at a stage where there is a bottleneck. Where it cannot control the bottleneck itself, it should seek to mitigate the power of whoever does control the bottleneck. This can require developing alternative suppliers, reconfiguring the value loop, or at the limit, creating a new value loop with a different bottleneck that the company can control.

In this case, the bottleneck is at the *create* stage, which, for now, GlowCap controls. Consequently, participants in this value loop would do well to consider the extent to which the "smart pill bottle" market will have sufficiently vigorous competition to prevent GlowCap from exerting pricing power over them. Alternatively, or perhaps in addition, they might consider participating in GlowCap's early-stage growth—less as an investment in a specific start-up than as a strategic option that can reduce the possibility of being in a disadvantaged negotiating position in the future.[20]

By breaking the bottleneck at the *create* stage in this value loop, GlowCap enables a larger one that depends upon the aggregation of data for populations of patients. This allows for analysis that can reveal the efficacy of treatment regimens in general, which is valuable to physicians who will know better what to prescribe, to insurers that can now establish formulas based on better data about what is likely to

work and for whom, and for pharmaceutical companies that can now devise more efficient and effective clinical trials.

The need for appropriate privacy protections, such as the Health Information Portability and Accountability Act (HIPAA) demands, can make it difficult to achieve other benefits arising from the aggregation of medical data. Therefore, the bottleneck in the value loop of population data is at the *aggregate* stage. Efforts to break this bottleneck include the State of North Carolina's PHARMACeHOME systems, which links pharmacy information with electronic medical records to track and identify issues with a patient's medication.[21] US Congressman Michael Burgess is taking that effort a step further with his draft legislation proposing integration standards for electronic medical records. The standards would mandate open and complete access to health data by authorized users, ensuring the discoverability and exchange of data—central to all successful IoT applications.[22]

In sum, companies can create value through both the value chain for each of their products or services, which determines performance, and the value loop for each product or service, which determines informational content. Today, few products or services are information-free, and so both typically feature in some measure.

Note, however, that should the *Aggregate* bottleneck in this value loop be broken, when it comes to data on patient compliance with medication regimens, the bottleneck will shift again: perhaps to *analyze*, as companies struggle to make sense of the volumes of health data they now control, or it may well shift back to the *create* phase as companies seek to add sensors to more functions and thereby collect more data. After all, the ability to aggregate data has value only when there are data to aggregate. Ecosystem players connected with efforts to aggregate patient data might want to take a lesson from expert chess players and think at least two or three moves ahead: When the bottleneck they control is relaxed, where will it be next, and how will that affect them? Without this strategic foresight, one might end up simply creating value that others capture.

How to win

Picking the right place to play in an ecosystem is only half the battle. After all, if there is significant competition at the bottleneck stage, then the value created at that stage is likely to be contested at best. From a company's perspective, an effective

antidote to competition is creating a strategy that is difficult for competitors to imitate, even when they know what your strategy is.[23]

As an aside, note that end-use customers in consumer markets capture not profits but, rather, consumer surplus. See *Power struggle*, in this issue, for a discussion of the determinants of value capture between companies and consumers.

Like the *where to play* question, understanding *how to win* turns largely on the careful application of existing principles, but with a twist: Not only must companies compete on the basis of their products—they must also be alert to the ever-expanding opportunities to compete on information.

The fitness-monitor market provides an illustration of different levels of emphasis on product and platform. Polar Electro, a Finland-based company, has been making some of the most technically advanced, generally available heart rate and activity monitors since 1977. FitBit, founded in 2007, started with basic activity trackers and has quickly branched out into more sophisticated devices. Each company's products provide information on user activity with a scale, scope, frequency, accuracy, and so on, according to the requirements of the targeted customer segments.

So far, this seems a straightforward story of performance-based differentiation and competition. When viewed through the lens of information-based platform competition, however, some potentially important differences begin to emerge. Both Polar and FitBit are creating information-based value loops, and each sits firmly astride the *create* stage of those loops. Yet each is fashioning a different type of ecosystem to complete the loop for its customers.

For example, at the *aggregate* stage, both companies make their Application Programming Interface (that is, API) available to third parties so that, subject to user approval, data can be combined and analyzed. Fitness research and corporate wellness programs make use of this functionality. End-use customers, in contrast, do not write their own programs but, rather, rely on a population of readily available aggregators assembled by Polar and FitBit, respectively. Polar's portfolio of data aggregators generally available to users consists of Google Fit and Apple® HealthKit.[24] In contrast, FitBit has almost 40 different health-data aggregator partners, some aiming to capture a broad range of customer data, others more focused on specific tracking tools for diet, weight, sleep, and so on.[25]

In addition, each supports behavior modification differently. Merely monitoring activity does not lead to lasting and effective change for most people.[26] To close the information value loop in the activity-tracker market, the analysis of activity must lead to changes in action, which is accomplished via augmented behavior technologies, and FitBit and Polar approach this challenge differently.

The careful application of social networking can help those who are less intrinsically motivated to make the necessary changes. Simple "gamification"—the

comparing of one's activities with a group of others—is typically ineffective and often counterproductive: Many of those who join such groups are already quite fit and active, and for those who most need motivation and support, being constantly told that one is at the bottom of the heap can be demoralizing.

FitBit enables a more nuanced approach, providing the user the ability to create or participate in carefully designed user groups—a form of *aggregation*. This seems better aligned with supporting behavioral change among those not already highly motivated. In contrast, Polar seems to focus more on sustaining intrinsic motivation, allowing the user to share specific workout results via social media, or to access training advice based on user performance.

Polar's ecosystem is more self-contained than FitBit's because Polar is competing largely on the differentiation of its device: It *creates* data for its customers. Customers can then save those data to information platforms, which in turn connect to a wider array of services that, collectively, aggregate, analyze, and enable action. Polar's bet appears to be that it will compete on the merits of its device, leaving to others the task of building the information ecosystem their device feeds. In contrast, the value loop that FitBit enables is more reliant on an ecosystem of commercial application developers and other users connected via the FitBit platform. Rather than feeding an ecosystem, FitBit seems to be building one. These differences imply very different drivers of long-term success.

For example, for FitBit's user networks to be effective, each user needs to be able to link up with other users with similar enough profiles, and that can require a large population from which to draw. Polar, on the other hand, is focused more on elite athletes. FitBit therefore depends to a larger extent on widespread adoption, while Polar must provide the performance and robustness demanded by higher-performance athletes. These differences are consistent with each company's pricing: At the low end, a FitBit monitor is priced at under $50 with a high end of about $250; Polar's entry-level product is over $100, with elite devices priced at $500 or more.

Where Polar is competing more on the basis of its product's performance, FitBit is competing more on the basis of the platform it has created. When competing on performance, a deep understanding of the needs of targeted segments is essential. In addition, tight control over every aspect of product development or design that affects the performance your most important customers value most is indispensable. In short, when competing on performance, relying on an ecosystem can be a high-risk strategy.[27]

FitBit's strategic challenge is quite different. Its success is likely to turn more on creating a very large ecosystem of aggregators and users in order to set up at least three positive feedbacks: More aggregators means more users; more users means more aggregators; and, thanks to the benefits of appropriate social networks, more

users means more users. Since smaller aggregators are unlikely to develop applications for multiple devices, and users are unlikely to use multiple monitors, FitBit is more dependent upon becoming a platform standard than is Polar, and so its willingness to invest heavily to draw large numbers of developers to its platform, and users to its device—and quickly—is likely to be a key component of long-term success.[28]

… the more they stay the same

The world of business, like many fields of human endeavor, can fall victim to the innate human desire for newness. It is for this reason that it is crucial to look upon the Internet of Things with both an open mind and a certain crusty skepticism. We need to be creative and inventive to make the most of the new ways in which companies can create value thanks to IoT technologies' new sources and types of information. Failing to capitalize on new sources of competitive differentiation and even entirely new business models might well leave currently dominant incumbents to the fate of so many before them: disrupted by those willing to embrace change.

Yet, of course, it is always possible to go too far. For every successful innovator, many more have failed because they forgot that despite the significance of the changes enabled by new technologies, there remain eternal verities that must be respected. In the case of the IoT, information as a new source of value does not change the need to capture value by competing and winning.

Companies are beginning to explore what the IoT means for them. Some changes will be incremental and relatively easy to adopt; others will be more nearly transformative and require a willingness to question some deeply held assumptions. In every case, our advice is to approach every IoT deployment with a clear understanding of the information value loop created by these technologies. It is the rise of information as a key source of value that suggests fundamental change.

Forewarned is forearmed, however: The need to capture value remains as acute as ever, and we advise that companies look at their positions in the information value loops they are creating with a pragmatic and practiced eye. The established principles of strategic differentiation, process flow, and network economics will go a long way toward revealing a path to long-term success.

It is by understanding both what has changed and what has stayed the same, and the importance of each, that we can find truth rather than merely cliché in the old aphorism *Plus ça change, plus c'est la même chose.* DR

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