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Order Matters, and Thus So Does Timing: Graphical Clocks and Process Synchronicity

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The purpose of this paper is, first, to review definitions of time; second, to discuss particular dimensions of time; and third, to relate those dimensions to graphical clocks. The value of such clocks for network analysis will be discussed.[1] The clocks for the integration of system networks will be computerized matrices and concomitant digraphs (graphical clocks). Such networks can be used to provide a standardized system clock to determine timeliness. This places events into a common system, which is timed by sequenced events. The coordination of broadly recurring sets of meaningful events characterizes synchronicity. Thus, timeliness is defined by system synchronicity.

Definition of Time

Early instrumental philosophers based temporal concepts on individual psychological and mental experience. Josiah Royce dwelt "upon the time consciousness of our relatively direct experience because," according to him, "here lies the basis for every deeper comprehension of the metaphysics both of time and of eternity" [Royce 1904, 401]. This is inappropriate since complex processes such as those articulated by digraph networks contain temporal relationships that need to be heeded by the socioecologi-

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cal investigator, whether or not a person experiences them, and the basis for a million year ecosystem cycle is not metaphysical musings about eternity. William James said that the brain process "must be the cause of our perceiving the fact of time at all" [James 1890, 382]. This is true, of course, but possibly misleading if time is attributed to the brain. This is so for two reasons. First, there must be an eventful world to perceive before there is time. Second, brain processes can be used to perceive time incorrectly.

"In modern paradigms, time does not flow, or go, or run from here to there in either a cyclical or linear pattern. It also does not bridge a spatial gap between points" [Hayden 1988, 330]. Neither is it a natural phenomenon. As anthropologist Edward T. Hall notes, our perception of time "is *not* inherent in man's biological rhythms or his creative drives, nor is it existential in nature" [1983, 45]. Time is the duration of motion between events, and it has no direction. Time measurement is a relative concept that relates one motion to the duration of another motion–a clock.

Temporal Dimensions

Process Time

Events in the actual world are processual. As Walter Neale put it, "One way to understand what institutional economists have been about is to see them as rejecting nouning and arguing for processual verbing. . . . Institutionalists . . . have used nouns; *but* . . . they have come as close as is perhaps possible to analyzing economies as verb processes. . . . The noun that sums it all up is a noun about verbing: *process*" [1982, 363-364, 368].

In terms of the temporality of a process, an event is a happening. It is an ongoing process or part of an ongoing process. The happening–the verb–creates time by its occurring. The philosopher K. G. Denbigh has commented on the noun-verb dilemma: "Things which have a material existence present themselves in two somewhat distinct aspects: (1) as being material; (2) as being capable of movement and of change in their qualities. These are reflected in language by the use of noun and verb respectively, and it is perhaps an accident of language that the substantive aspect of things seems to carry with it a greater sense of reality than do their actions or potentialities" [1975, 27]. Process time is not a reified, ab-

solute, or spacialized time. It is an actual time. "The process does not take any time to occur only because time is created by its occurring. Before its occurring there is no time . . ." [Sipfle 1969, 511].

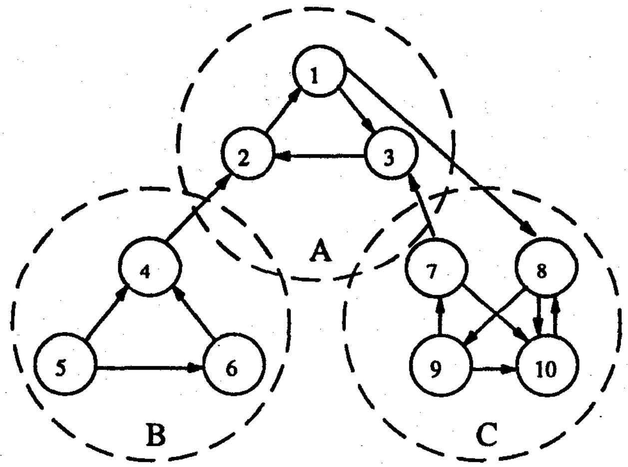
A process approach to time does not attempt to make the world into instants and moments that contain unique events. There is no event that we would call the event in the present moment of time. Instead, there are a multitude of ongoing process flows—flows as diverse as energy and protein flows in wetlands, money flows at retail counters, and weapon deliveries to the war zone. To assume that the present is a unique event in some passing moment, in addition to being an unrealistically narrow focus, ignores process. As the philosopher Henri Bergson wrote, "Real time has no instants" [1975, 226].[2]

The recognition that real time has no instants reinforces Stephen D. Parsons' adverse criticism of G. L. S. Shackle's conceptualization of time as a series of instants or moments, "i.e. a sequence of 'nows'" [Parsons 1991, 414]. Parsons argues that the problem with Shackle's understanding of time is that "despite the emphasis on activity, passivity is inherent in the construction of time as a sequence of 'nows' which happens to us" [p. 415]. This means, according to Parsons, that "time is something that happens to me. Time passes, it stretches before me as a sequence of 'nows' which I hop along" [p. 419].

Digraph as Analytical Tool

The digraph is a tool for conducting inquiry on processes (see Figure 1). The digraph of diverse ongoing events provides for unity and meaning, illustrates process sequence, and becomes the process's temporal data.[3] We can observe in a digraph process that numerous durations are happening simultaneously. There is not *a* duration (thus not one time); instead, there are numerous events and numerous durations. Alfred North Whitehead stated that if the investigator chooses one duration as the process clock, a duration is defined as a complex of *partial* events, and the entities that are components of this complex are thereby said to be simultaneous with this duration [Whitehead 1920, 332]. We shall see later, however, that to select one duration as the process clock would be to ignore the reality of the process approach, that is, differences in time and time scales among processes.

Figure 1. Digraph of Overlapping Processes



Process Clocks

Since time is the duration of process happenings, the digraph can be used not only as a description of a space-time process, but also to determine timeliness of the deliveries in the various processes.

Real time delivery clock: If an event is the delivery of a processual flow, the duration is measured by a related flow in the process.

For example, if a trucker is trying to determine when the truck needs to return to the field before a combine bin is full during a wheat harvest, the timeliness of return is determined by the yield of the wheat crop (with a given technology). In coordinating hauling needs, the flow of grain into the bin is the real flow consideration. The rate of flow of trucks from town to get the grain is a real flow comparison with the grain flow. Trucks must return at a faster rate if the wheat yield is 60 bushels per acre than if it is 30. So the real time clock is based on trucks per bushel of wheat flow.

As another example, assume that 470,000 gross tons of scrap metal are delivered to a mini-steel mill, and throughout the same duration, the mini-mill uses 780,000 kilowatts of electricity for its electronic arc process that makes steel from the scrap. This means the real duration of scrap metal delivery is 780,000 kilowatts, and the real time clock is 1.7 kilowatts per ton, not minutes per hour.

The use of concepts such as years, hours, and minutes has misled economists about processes because such concepts encourage a perception of flowing time rather than real units. The amount of time occurring during an hour can be increased or decreased by increasing or decreasing the process events and activities.[4] The clock in a digraph is not the edge between nodes, as might be suggested by linear time concepts. Instead, it is the relationships among deliveries that flow among nodes. Timeliness is the coordination of various flows within a process or among the processes of different systems.

Real systems are polychronic: Edward Hall categorized people according to whether they had a monochronic or polychronic view of time. He then compared and explained the societal consequences of the two different temporal constructs with regard to authority and control, decision making, symbolic images, personal relationships, bureaucratic organization, and so forth. Hall found that Northern Europeans and Americans have a monochronic view of life, although they are surrounded by numerous concurrent processual transactions. This "monochronic time is arbitrary and imposed, that is, learned. Because it is so thoroughly learned and so thoroughly integrated into our culture, it is treated as though it were the only natural and logical way of organizing life" [Hall 1983, 48-49]. This has led Americans to "think of time as a road or a ribbon stretching into the future, along which one progresses. The road has segments or compartments which are to be kept discrete ('one thing at a time')" [Hall 1959, 28].

Paul M. Lane and Carol J. Kaufman applied Hall's concepts to the common analysis of consumption behavior and found that the assumption in neoclassical economics is that people do one thing at a time [Lane and Kaufman 1990, p.4]. In fact, the neoclassical temporal construct is monochronic to the extreme. The metaphor of time in neoclassicalism is not only movement along a line, it is movement along a straight line. Along this line are discrete segments in which events take place one after another, each following its antecedent. Neoclassicalists carry this reification over into applied time studies by arbitrarily attempting to eliminate overlapping transactions and concurrent activities.

This reification is illustrated by the temporal construct in time-use studies [Juster and Stafford 1991].[5] Neoclassical time-use surveys force processes into a monochronic, structured clock time made up of neatly segmented, linearly fused blocks of time. These

surveys usually divide a 24-hour day into segments such as 15-minute blocks and require participants to report only one activity in each block in their time diary, regardless of whether the participant is involved in conjoint activities. The code manual gives specific instructions to eliminate multiple or concurrent activities when respondents are self-reporting.

Unlike North Americans, the Japanese have a polychronic view of time, according to Hall [1983, 53-58]. Thus, their time surveys report all activities as being done simultaneously. "In the Japanese data, for example, all activities are recorded even when they are being done simultaneously, with the result that the total amount of time allocated to different activities comes to more than a 24-hour day" [Juster and Stafford 1991, 515]. The Japanese respondents recorded according to reality, but Juster and Stafford aggregated as if activities can only take place one after another along a 24-hour line. They warn that to achieve the 24-hour day from the Japanese data "takes a good deal of arbitrary reallocation of time uses . . ." [p. 515]. Their arbitrary method applied to the Japanese data was to reduce all time uses proportionally except for the total time reported for sleep and for market work [pp. 515-516].

Monochronic survey design techniques create a bias toward reporting physical activity [Lane and Kaufman 1989, 5]. This reinforces the materialistic conceptuality of Newtonian time that still dominates the neoclassical paradigm, which is even more disturbing to me than the arbitrary treatment of data. It means that these studies are ignoring the most important personal and societal activities such as thinking, discussing, valuing, symbolic analysis, application of belief criteria, moral and ethical decision making, and so forth. These activities are at the economic center.

The activities of persons and families are polychronic, and higher order processes such as those that constitute economies, societies, and ecological systems are even more polychronic. Let me clarify by describing a relevant example. A corporate executive from an international investment firm is driving home from work. While driving, he is listening to international news briefs on a compact disk that he receives daily, and coincidentally, he is talking on his car phone. If a time surveyor requires the executive to list only one activity, he may list driving home and ignore the concurrent processing of news information and the investment deals being made on the phone. If the surveyor requests the executive to

list all the activities, and if the drive home takes 30 minutes, then the driver has 90 minutes of activity in a 30-minute period. This is contradictory. This is a contradiction however, that we need not worry about resolving because it is an artifact of the monochronic approach. Let us clarify through additional complexity. The three activities mentioned do not indicate all processes in which the driver is involved, nor do they indicate which processes are of interest. Other processes include: (1) the many physiological processes that are processing and generating durations–coronary, kidney, blood circulation–to mention a few; (2) the auto fuel consumption process with its far-flung accompanying processes of pollution, automobile manufacturing, and Middle Eastern oil production; (3) the family gathering for the evening meal; (4) suburbanization; and so forth. Process intertwined with process intertwined with numerous other processes–that is the real world of driving home.

Even if we toss out the monochronic approach to time, the question of which time-generating process to study remains. The answer, as institutionalists know, is determined by the problem we are attempting to solve. If the problem is one of species survival in an area of Africa populated by hunters and gatherers, then the activity of the driver in Lincoln, Nebraska, that is of interest is the phone call in which the executive concludes a deal to introduce cattle into a new area of Africa. This will mean the destruction of species that compete with cattle and the consumption of vegetation by the cattle. Through this process, the sources of food for hunting and gathering tribes are destroyed [Hitchcock 1992]. Thus, the events and durations are generating times of doom for many species and tribes. As John Dewey clarified, time analysis is dependent on the aspect of the problem that is to be considered [Dewey 1940, 423].

When we turn to study real world problems, in real world social processes, the monochronic approach of neoclassicalism serves as a misleading reification that leads to debate about other misleading reifications. Elliott Jaques clarified this point when he wrote:

> Much of the debate about the nature of time is a fruitless debate, arising from the reification of time. We often treat it as a concrete thing. If we did not, we should not get into arguments about the passage of time, or the flow of time, or about the future flowing into the present into

> the past, or about whether the arrow of time is unidirectional or bidirectional or directional at all, or whether there is a time arrow, or about the possible effects of entropy upon time. These formulations confuse the concept of time as a positional noun and as a universal category, with the experience of the concretely particular events or processes involving concrete particular things; which are the phenomena from which we construct the concept of time.
>
> It can be stated quite simply that time is neither like a river nor like an arrow. *Tempus fugit* is not true . . . nor does time go in any particular direction, because time per se does not go anywhere or point anywhere [Jaques 1982, 51].[6]

With real world problems, reification is not sufficient. With real processes, numerous nodes are simultaneously transacting different deliveries and thereby creating numerous different time dimensions. The temporal character of processes is polychronic and multidimensional.[7]

The Multidimensional Temporal Character of Processes

For polychronic synchronization to provide order and timeliness in a process, temporal differences within and across processes need to be recognized. Temporal differences that complicate the maintenance of synchronicity will be discussed next.

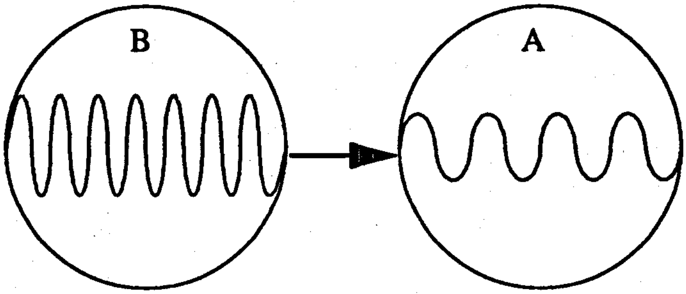
Real time: dynamic change for stability: Events and deliveries must change on a real time basis to maintain a system. This is part of a more general temporal principle often ignored in economics, a discipline in which a duality is often maintained between dynamics and stability. In real processes, dynamic change is necessary to maintain stability. In our automobiles, the carburetor governor changes the flow of fuel as the load on the engine changes in order to maintain a stable speed. In the modern economy, changes are often made in hope of maintaining a stable economy. These include legislative changes in tax policy, central bank changes in the cost and availability of liquidity, and the operation of automatic stabilizers that respond to change by changing flows such as unemployment compensation payments.

Real world processes are not equilibrium systems. Thus, decisions, responses, and reflections are made on a real time basis to maintain stability and the re-creation of processes. Dynamic control must change the *rates* of particular events, reactions, or trajectories relative to the unconstrained rates [Pattee 1973, 83-84]. The collection of elements and components (represented by the nodes in the digraph) persist largely because of the rates of their deliveries and responses to change.

Different processes: Different processes operate at different temporal rates. Crucial to coordination and order is the regulation of delivery from an adjoining process in a manner consistent with the temporal frequencies of the receiving process. This concept is represented in Figure 2. If we view system processes A and B (from Figure 1) as whole processes, without respect to their internal pattern, we see that B has a higher frequency within its process than A. Thus, the frequency of B cannot be left unmodified in its deliveries to A because otherwise, A would be disrupted. Figure 1 illustrates that a low frequency process is isolated from the high frequency of another process. Several examples come to mind. One is the United States Supreme Court's decision with regard to market transactions in the economy. The transactions are occurring at a very rapid pace, while the court issues opinions at a much slower rate. The court would be overwhelmed if it did not isolate itself from the high frequency signals of economic transactions. Another example is the relationship between ecological systems and economic systems. Ecological systems operate on large, slow moving time scales. Their response time to impacts and disruptions is slow. Thus, without managerial control to protect them from the rapid pace of economic systems, ecological systems will be destroyed. The instrumental philosopher Bryan Norton recently wrote "that environmental management should focus on trends in the behavior of parts and that 'ecological breakdowns such as the dust bowl occur when rapid changes in social trends overbound the parameters of normally slower change in larger systems" [Norton 1990, 119].

Successional time: Succession adds another time difference. Economics has long been concerned with the succession of alternative conditions and appearances. The business cycle, with its succession from recession to recovery to boom to recession, is one case. The financial stages of a business provides another example. Although the technology and production process may remain the

Figure 2. Process Digraph of Different Process Frequencies. High Frequency of B Is Modified for Low Frequency A

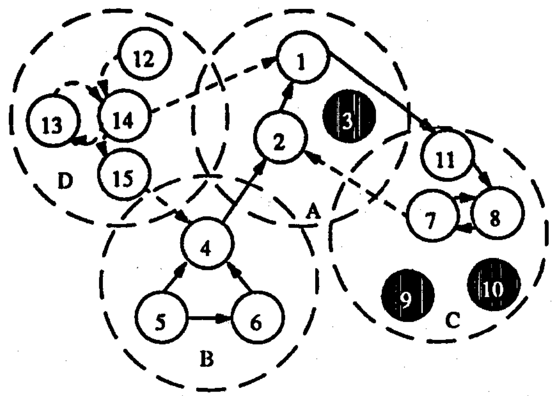


same, a company may pass through numerous financial stages, beginning with seed capital, through periods of negative cash flow, to positive cash flow, and finally to the need for expansion capital.

Although common in economics, consideration of the temporal dynamics of succession did not take place in ecological studies until the turn of the century. The succession from weeds to grass to trees following ecological disruption is an example familiar to most of us. William Mitsch and James Gosselink offer another example: In Midwestern prairie pothole marshes, the vegetation can be wiped out by a population explosion of herbivorous muskrats. New emergent vegetation cannot become established until a dry year exposes the soil. A typical succession of species follows until robust cattails out-compete them. This sets the stage for another muskrat explosion. This cycle has a six- to eight-year frequency that depends on both the biotic vegetation-muskrat interaction and the biotic wet-dry climatic cycle [Mitsch and Gosselink 1986, 158]. Successional time has played a central role in ecological studies. However, like the economy, the ecosystem cannot be explained fully by successional time [O'Neill et al. 1986, 23]. There is also evolutionary time.

Evolutionary time: The time dimensions of a process are based on the sequence of events and on the succession of dynamic processes. Evolutionary change, however, connotes a magnitude of change as to alter time scale. An evolutionary clock is not locked into a sequential time frame of particular components and

Figure 3. Evolution of Figure 1 with Acquisition and Loss of Nodes and Deliveries. Loss of Nodes Indicated by Shaded Circles. New Deliveries Indicated by Dotted Lines. Nodes Lost are 3, 9, and 10. Nodes Gained are 11, 12, 13, 14, and 15



deliveries or into a succession of alternative collectives. *All* is in flux, including time. Evolutionary change can also be expressed through digraphs. Figure 3 is presented as an evolution of Figure 1. Figure 3 illustrates that the system (1) has become more complex, (2) has evolved new nodes and deliveries, and (3) has lost particular nodes and deliveries. This evolution creates new times and new durational relationships. A well-monitored digraph allows us to track and evaluate evolutionary change. The complexity of a system digraph depends on the extent of evolution under consideration. The greater the evolutionary activity, the more components die out and the more new components evolve; the less the activity, the less complex the digraph. Concepts such as evolutionary economics, ecodevelopment, successive eras, development, historical stages, cumulative circular causation, coevolutionary development, and growth can be expressed and applied much more accurately through comparative digraphs. In addition, such an expression allows for the conversion of the digraph to its boolean matrix in order to take advantage of additional analytical techniques.

Social Time

Thus far, temporal coordination has been discussed in terms of "real time," that is, the coordination of active real world processes. Instrumental policy, however, is concerned with changing real world processes. In an advanced technological society, humans become the gods. Knowledge of our past mistakes may make intelligent analysts want to reject the task of synthesizing change. Reality, though, forces us to recognize that for better or worse, it is our task to create such change. Our policies determine which species are to exist, which children are to go hungry, how soon the ozone cover will be depleted, the incidence of cancer, the flow of income and investment, and so forth. Thus, the task goes beyond simple coordinating processes; the task is to determine them. With this recognition, we step beyond real time to social time through which societal decision making determines order, timeliness, nodes, and deliveries. In terms of digraph articulation, the task is one of design *and evaluation* of alternative digraphs.

Institutionalism and Time Analysis

Adequate institutional analysis cannot be completed without accounting for processual time. John Dewey stated that "the nature of time and change has now become in its own right a philosophical problem of the first importance" [1940, 423]. Yet, a perusal of modern institutionalist literature provides few examples of use of temporal analysis or of how temporal concerns have been handled in particular studies. Temporal analysis needs to become more explicit and form an integral part of institutional studies.

Examples of Carelessness

Some institutionalist studies, many of which are not explicitly allied with the Newtonian materialistic concept of time, are replete with terms and phrases that associate closely with that concept. One example that is common is the treatment of "historical time." This concept is based on the assumption that time is passing, although time does not in fact pass. Treating time as space also appears. An illustration is the term "over time." Is it possible to be over that which is not spatial? Time is not spatial. Time is found

because of process; process is not found "over time," or "in time," or "through time." To make time prior to process is to make time a metaphysical enigma.

Some phrases disassociate time from events and duration. One such phrase is "a point in time." Yet real time has no points. There can only be time if there is duration between events, and there is no duration at a point. A similar case can be made against the phrase "at a particular moment in time." Another that makes the same disassociation is the phrase "Time is money." Time is not money. Money processes create time; time does not create money. A similar disassociation is made with the statement "Fiscal policy takes time." Fiscal policy does not take time. It creates time. As Whitehead stated, "The disassociation of time from events discloses to our immediate inspection that the attempt to set up time as an independent terminus for knowledge is like the effort to find substance in a shadow. There is time because there are happenings, and apart from happenings there is nothing" [Whitehead 1975, 341].

Sequences of Events, Networks, and Timeliness

Thorstein Veblen advised us in his 1898 article "Why is Economics Not an Evolutionary Science" that socioeconomic analysis should proceed by laying out the sequence of events and decisions in a system. He developed a network concept in his 1923 essay "The Country Town" [Stinchcombe 1988, 128]. Karl Polanyi's ideas on economic process are consistent with Veblen's on the sequencing of events and decisions in a social network [Polanyi 1957]. John R. Commons further developed Veblen's ideas by incorporating the idea of timeliness. He pointed out that to understand a system's needs, we "must know *what*, *when*, *how much* and *how far* to do it at a particular time and place in the flow of events. This we designate the principle of timeliness" [Commons 1968, 379]. Matrices and concomitant digraphs can be utilized to complete the description of social networks, as has been the case in sociology and anthropology. As stated above, such digraphs can be utilized as graphical clocks. The value of such graphical clocks for institutional research is to determine timeliness in the description and evaluation of socioeconomic systems.

Much of the research found important by institutionalists is dependent on the concept of timeliness. A description without an

understanding of the timeliness of deliveries to the nodes in a real process would not be considered complete. Likewise, analysis of either (1) the agents within a system, or (2) recommended policy requires an understanding of what, when, how much, and how far. Discretionary decision making requires providing for the real time dynamic response to provide for process stability as described above.

One of the few serious attempts to judge timeliness as suggested by Commons was found in a recent study on import canalization in India [Das 1992]. A canalizing agency is a service organization concerned with the delivery of import items to the appropriate manufacturing nodes. It does not have any direct involvement in production. It engages in importing bulk raw materials and intermediate goods and in selling them to indigenous manufacturers, thus serving as a link between foreign exporters and indigenous manufacturers. Table 1 is a summary of the experience regarding timeliness of delivery of various commodity flows by such canalizing agencies in India.

In sociology, where most of the network analysis consistent with Veblen's advice has been done, the networks have not allowed for succession or evolutionary temporal frames. The digraphic techniques suggested above will allow institutionalists to complete the successional and evolutionary analyses that were, of course, Veblen's main concerns. Succession and evolutionary change were also central in Polanyi's process transformation.

Table 1. Experience Regarding Timeliness of the Deliveries

			Ranking				
Commodity	Excellent	Good	Tolerable	Poor	Downright Bad	Total	Average Rank
Edible oil	–	5	6	–	–	11	2.5
Paper (newsprint)	–	–	7	3	1	11	3.5
Steel scrap & sponge iron	–	5	6	1	–	12	2.4
Natural rubber	–	2	5	1	–	8	3.3
Iron and steel	–	–	4	6	6	16	4.1
Non-ferrous metals	–	5	5	1	1	12	2.9
Total	–	17	33	12	8	70	3.1

Note: 1 = Excellent; 2 = Good; 3 = Tolerable; 4 = Poor; 5 = Downright bad
Source: Das [1992].

Technology

Technological change is an important factor in most institutional analysis. Its importance to time and timeliness needs to be recognized and incorporated into future analysis. As noted in the wheat cutting example above, real time delivery clocks are dependent on a given technological context. A change in technology alters the amount of time (alters the events, durations, and happenings). With the change in activities, the meaning of temporal concepts such as person hours and person years changes. An example of change in temporal characteristics due to new technology is provided by global wireless communication systems. The events happening changed, the frequency and rate of such events changed, the duration between events such as change of money was shortened, and processes such as payment and monetary processes changed. Electronic money so changed the temporal rate and ease with which money can be transferred around the world that the formation of new institutions such as the G-7 was necessary for the continued relevance of policy. These kinds of evolutionary changes can be articulated by the use of graphical clocks as illustrated in Figure 3.

Conclusion

There are numerous times and real clocks in a process, as there are numerous ways that a process might be ordered and coordinated. Digraphs and their matrices can be used as graphical clocks for understanding and synchronizing the order and timing of processes.[8] The common time unit is the network (digraph) of the system. *Within a process*, events are the deliveries among process nodes (institutional, technological, cultural, and environmental). *Process stability* is maintained through dynamic process change. *Process succession* is the succession of alternative conditions and new collective sets. Business cycle conditions and ecological succession of species are examples. *Process to process* deliveries require frequency adjustments to make deliveries consistent with receiving processes. *Evolutionary change* means a drastic change in the process components and its deliveries, dynamics, and succession. All of these process occurrences create a complexity of temporal dimensions. To articulate the complexity is crucial in order to describe, understand, or plan a process; and

graphical clocks should prove to be useful instruments for such describing, understanding, or planning. Digraphs provide for common networks that will permit us: to computerize the data bases that describe processes, to model whole collectives, to determine the thresholds of deliveries, to monitor change, to allow for real-time order and response, and to conduct network evaluation.

Notes

1. This paper is an extension from my earlier paper on time in which I concluded that graph theory and digraphs held the most promise for further temporal analysis [Hayden 1988, 356-357]. Paul M. Lane and Carol J. Kaufman utilized findings in that article in their research on time theory [Lane and Kaufman 1989], and this paper will use their theoretical extensions, although in a different context.
2. Many philosophers have argued that the belief in past, present, and future is illogical. Without reviewing that literature here, it can be stated that these conclusions follow from the unsubstantiated assumption that time is a flow of moments with present events taking place in a passing moment. In this metaphor, a present event captured in a moment would become a past event as the moment flowed into the future to become the past; this is not logically satisfying.
3. There is not a common mathematics to describe a process because of the dissimilarity of the parts, the transformations, and the complex response and control entities. A process is not a set of simultaneous equations, nor is it a linear transformation. There may be a set of similar ecological entities, for example, a deer population that regularly replicates itself. That replication may be influenced by government policies guided and constrained by human beliefs. Derivatives, integrals, and aggregation mathematics do not allow for the modeling of gaps in commonality. Graph theory and boolean math does, however, allow for such gaps to be closed in a manner that provides for common networks.

4. During a work shift that I observed, the work activity had been drastically reduced below normal, and there was little for the workers to do. After the shift, one worker was heard to say, "I had nothing to do; time was slow." More correctly, time had been destroyed. Durations were not being sensed because they no longer existed. Time was less than slow; it was dead.
5. Another example can be found in the May 1992 *Papers and Proceedings* of the American Economics Association. Three papers on "Intertemporal Dimensions of International Economics" assume the neoclassical conception of linear time. There is no "intertemporal" analysis, that is, analysis *between* different or similar time constructs. In fact, one paper implicitly assumes the temporal constructs of Chile and Texas to be the same [Baldwin and Oaxaca 1992, 168-185].
6. Institutionalists will be interested in the discussion by Elliott Jaques on the dichotomies involved with the experiences of time, as well as his discussion on the difference between dichotomies and dualities with regard to time [Jaques 1982, 197-221].
7. Even in economics that attempts to integrate time into analysis of expectations, the polychronic and multidimensional character of time is ignored. An example is an article by Randall Bausor that concerns the expectations governing choice [Bausor 1984, 360]. Bausor assumes that "time dictates behavior" [p. 360]; yet, as emphasized above, behavior creates time. At a more basic level, he assumes that time has a "forward motion" with "moments" and "instants" [p. 360] in a world where "causation runs strictly forward" [p. 362]; yet, time does not flow into the future (or into any direction), nor is it constructed of moments and instants. In the final analysis, however, Bausor's work does not depend on time. This point can be demonstrated with the following sentence from his article: "It is with the unreasonable reactions from the heart that historical analysis must be most concerned, for they constitute the central events of kaleidics and account for the most amazing distinc-

tions between historical-time and logical-time analysis" [p. 371]. The word "time" could be left out of the sentence without changing his intended meaning. Indeed, to do so would clarify the meaning. If we, however, actually introduce temporality by substituting the correct synonym for time, the sentence loses its meaning. If "duration" is substituted for "time," the sentence is confusing. What is "historical duration," or what is "logical duration"?

8. An article by Norman Clark [1991] on the theory and processes of information in organizations is consistent with the time analysis presented in this paper. Future analysis should integrate the two.

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