The Evolution of the CASCON Community: A Social Network Analysis

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Abstract

The networking form of organizations is becoming prevalent and worthy of study in every realm of social structure. In this paper we focus on the way this statement holds in the context of collaborative research networks. In order to do so, we analyze a specific network of researchers by looking at the CASCON conference paper co-authorship structure. CASCON is an annual International Conference hosted by the Centre for Advanced Studies, IBM Canada Software Laboratory. We utilize the Social Network Analysis framework to understand what characterizes the social structure of the CASCON research paper network and, based on our findings, we offer preliminary insights regarding potential actions that can be taken to further develop the CASCON and other similar communities.

1 Introduction

The fabric of society is based on networks [2]. Our social and professional lives are embedded in interactions with manifold players that are linked together in web-like relationships. Castells has argued that the world is entering an age that “provides the material basis” for the “pervasive expansion” of what he calls “the networking form of organization” in every realm of social structure [10]. Wellman calls this change a shift from a group-based to a network-based society [29].

This pattern also holds for researchers who are not autonomous and self-guiding actors, but work within a social world [3]; that is, networks, that they attempt to make sense of and/or shape and influence to some degree. In order to understand knowledge creation in research endeavors, we therefore need to understand the structures of the networks that unfold around research activities [2, 4]. These structures can potentially provide us with an understanding of the individuals and networks which influence knowledge and cultural production issues [3, 5]. This implies that the structure of networks as an independent variable impacts on the content, output, and/or performance of the network. In this paper our focus is on the publications of one specific forum, the CASCON conference, the annual conference of the Centre for Advanced Studies (CAS).

The mandate of the CAS when it was established in 1990 was to foster collaborative work between IBM Toronto and university researchers from around the world [18]. The first CAS Conference (CASCON) was held one year after CAS was formed in 1991. The focus of this conference was, and continues to be, bringing together researchers, government employees, industry practitioners, and technology users in a forum for sharing ideas and results of the CAS collaborative work [18]. In this paper we examine the issue of research collaboration by exploring the structure of the CASCON community as defined by papers presented at every CASCON to date (from 1991 until 2009).

The CASCON conference is an interesting object of study in this way because it is an annual
forum for research collaborations from within a collaborative research centre (CAS) [18]. Rather than focusing on a narrow topic area in computer science research, CASCON’s mandate is broader, covering many topics in computer science and software engineering with a focus around industry / university collaborations. It is therefore interesting to understand what kind of unique structures exist within the CASCON network as a result of the fact that it was designed to support an underlying research centre, CAS.

In our social network analysis (SNA) of the patterns of co-authorship in this community, we cover the whole time period of CASCON, from the beginning in 1991 to 2009. Thus, we use a longitudinal view of 19 data points (i.e., annual conferences), which represents all the papers published in the proceedings of and presented at this specific conference. In order to understand the CASCON community better, we focus on the following issues:

- What characterizes the social structure of the CASCON research paper network?
- What insights do the SNA of CASCON publications provide for potential actions that might be taken to further develop the CASCON community?

The rest of this paper is organized as follows: in Section 2, we present a review of the social network analysis (SNA) literature and discuss the notion of social capital and its structural determinants. In Section 3, we present our research method and provide an overview of the data collected. In Section 4, we use the frameworks presented in Section 2 to analyze the CASCON co-authorship data. Results are described in Section 5 and, in Section 6, we conclude and present suggestions for future research.

## 2 Relevant literature

### 2.1 Social Networks

Scientific research is often a collaborative process: bibliometric studies over the past two decades have shown a continuous increase in the number of co-authored papers in every scientific discipline as well as within and across countries and geographic areas [27] and, specifically, within the computer science research community [24]. This raises the question of the manner in which the various authors interact in working to develop and publish such joint work.

One way to look at joint authorship is through the use of Social Network Analysis (SNA). Network theory in general is concerned with networks of nodes and links. Social network theory (which can be considered a specialization of network theory) focuses on nodes as social objects. The links in social networks depict various kinds of relationships including collaboration, kinship, shared ideologies, economic exchange, or communication, among others.

We find SNA to be particularly useful in analyzing the typically informal, non-hierarchical network that characterizes the way in which researchers choose to work together, given that no formal organization chart could ever be meaningfully constructed of such a diverse network. At the same time, we accept the basic assumptions and premises underlying SNA: (1) nodes and their actions are interdependent on their relational structure and each node is not viewed as an independent autonomous unit; (2) links between nodes are channels for transfer or flow of resources (material or non-material); (3) the network structure is an environment that provides incentives, opportunities, or constraints on individual action; and, (4) network models conceptualize structure as a lasting pattern of links between individual nodes. This pattern persists as a relationship beyond the time at which it formed [28].

In this article we follow the methodology used by Newman [17] and analyze the co-authorship, in our case, those papers presented at the CASCON between 1991 and 2009. The unit of analysis is therefore any paper that was published in the CASCON proceedings during these years. Hence, the various authors are the nodes in our analysis, and any link (relationship, or tie) between nodes indicates a joint publication between the two authors. As such, we assume that co-authorship is evidence of an intentional relationship among the authors.

In examining the network in such ways, we make an implicit assumption – that the structure matters in some way, and that it is this that makes it worthy of research attention. Support for this assumption can be found in the work of researchers such as Kilduff and Tsai who claim that “the network of relationships within which we are embedded may have important consequences for the success or failure of our [research] projects” [16].
Social network theory and analysis provide an important means to understand the interactions within network structures and the exchange of content that flows through these network relationships [16]. Exchange of resources within this network’s relations is facilitated by the use of different kinds of capital (e.g. financial capital, social capital etc.). In the next section, we deal with social capital which plays a crucial role in the facilitation of many types of resource exchanges across social networks [19].

2.2 Social Capital

Social capital is a concept that is being increasingly used in sociology, management, and public policy [19]. The idea that involvement and participation in broader social structure can have positive consequences for the individual and the group is not a new idea in sociology [19], but the recent interest in the concept of social capital was sparked by the work of Bourdieu [2] and Coleman [11]. The concept of social capital has been used in education, sociology, organizational theory, political science and management. It has been used to explain and predict different phenomena such as human capital [11], job promotion [8], and research work [2].

There have been various reviews of social capital [1]. We wish to discuss some of these issues now, in relation to the research questions presented above. Following Bourdieu [2], we define social capital as “the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition - or in other words, to membership in a group.” Or, as Putnam [20] puts it: “Just as a screwdriver (physical capital) or a college education (human capital) can increase productivity (both individual and collective), so do social contacts affect the productivity of individuals and groups”.

It is important to note that when analyzing research-related knowledge creation (such as that presented at an annual conference), one of the factors that researchers have noted as critical is social capital [3]. Within this context, Sandefur and Edward argue that there are three benefits arising from social capital: information, influence or control, and social solidarity [23]. Information benefits arise from the relevance, timeliness and trustworthiness of the information provided. Influence and control benefits arise from actor’s (in this case, author’s) ability to influence others and the ability of the actor to be free of others’ influence. Social solidarity benefits arise from mutual trust and commitment among actors.

2.3 Structural Determinants of Social Capital


Structural holes occur when a node in a network is connected to two actors that are not connected to each other. Closure occurs when all actors in a network are connected to each other. Such a network is regarded a cohesive network [11].

Structural holes and closure are conflicting arguments in the sense that when all contacts of an actor are connected to each other, the actor has a full closure in its network and when none of its contacts are connected to each other it has the maximum value for structural holes.

When looking at how to combine those two approaches, one prevalent explanation maintains that structural holes and closure are complementary rather than competing mechanisms [8]. In this view, it is argued that groups need to reach diverse information resources from outside, but also individuals within groups need to share this diverse information with each other in order to be effective. When there is competition (in an author network those can take the form of other conference venues), structural holes can create social capital, but when there is need for cooperation (sharing of resources, exchanging ideas and etc.) closure creates social capital [9,14]. For example, in their study of R&D teams, Reagans and Zuckerman [22] found that the closure in the network of the groups they studied increased the productivity of the groups.

The bottom line is that the networks with structural holes and those with closure are competing. Both of these network structures provide different mechanisms for sustaining social capital in the network. Coleman’s view of social capital stresses the positive effects of cohesive ties (ie,
closure) in promoting a normative environment that facilitates trust and cooperation between individuals [11]. On the other hand, structural holes theory [7] insists that social capital stems from the brokerage opportunities created by diverse ties. While the fact remains that both network structures have demonstrated the production of social capital, through different mechanisms, in this paper we look at which mechanism has evolved within the CASCON community, and the potential implications for the future of the CASCON community.

3 Research method

Before presenting a social network analysis of the CASCON community, we describe the data set in more detail and the method by which it was analyzed. We gathered data from the ACM Digital Library for each paper published from 1991 to 2009 including title, year, authors, and number of citations. The data extracted was imported into an Microsoft Access database for initial basic analysis.

Figure 1 shows the number of papers published each year from 1991 to 2009. Prior to 1997, all researchers participating in CAS were expected to submit papers to CASCON and most papers were accepted. In 1997, acceptance rates dropped and have continued to be in the 25%-40% range since then (except in 2007 in which 42.8% of papers submitted were accepted)\(^1\). In 2006 and 2007, papers from a CAS Dublin workshop were included in the proceedings (6 papers in each year) which explains the slight increase in those two years. From 1997 to 2009, the number of papers in the core CASCON conference (not including the papers from the CAS Dublin workshop) has ranged from 14 to 35 with an average of 22.6 papers per year from 1997 to 2009. The average number of papers per year from 1991 to 2009 is 33.8. The total number of papers published from 1991 to 2009 is 657.

There are 1101 authors who have published in CASCON between 1991 and 2009. Of the total number of 657 papers, 183 (27.8%) were singly authored while 192 (29.2%) had two authors. The rest were authored by more than two colleagues with 40 papers having 6 or more co-authors. The most authors to co-author one papers is 19 while the average (including singly authored papers) is 2.6 co-authors per paper.

Figure 2 shows the percentage of papers with different numbers of co-authors (from 1 to 9+) by year. The lowest blue band is the number of singly authored papers as a percentage of the total number of papers published that year. While, there is significant fluctuation year-to-year (due to the small size of our sample), there is a trend to lower numbers of singly authored papers from 1991 to 2009 and an increase in multiply authored papers. From 1997 to 2009, the majority of papers each year have 2-4 authors. This trend is in line with previous research that has witnessed a steady increase in the number of multiply-authored papers in computer science extracted from the DBLP database from 1936 to 2005 [24].

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\(^1\) Statistics obtained from hardcopy versions of the Proceedings.
We also looked at citations and found that CASCON papers have, on average, 75% of the citations of those in other conferences and workshop series in computer science (see Table 1).

<table>
<thead>
<tr>
<th>Venue</th>
<th># of Papers</th>
<th># of citations</th>
<th>Avg citations/paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conferences / Workshop Series in CS (as of Dec. 2007)[21]</td>
<td>1,752,000</td>
<td>585,000</td>
<td>2.99</td>
</tr>
<tr>
<td>CASCON (as of CASCON 2007)</td>
<td>612</td>
<td>1377</td>
<td>2.25</td>
</tr>
</tbody>
</table>

Table 1: Average CASCON paper citations compared to other conference papers up to 2007

This data indicates that, while CASCON is unique, it is not tremendously different from other computer science conferences in some regards.

We also performed social network analysis (SNA) of the CASCON co-authorship data. As mentioned above, SNA is concerned with understanding the nodes and linkages in any network, where the nodes are data points (in our case, authors) and the linkages are evidence of some form of connectivity between the nodes (in our case, two nodes are connected if the authors represented by the nodes have co-authored a paper at CASCON). For the initial visual analysis in this study, the co-authorship network for all the papers published as part of CASCON proceedings was drawn using the software program Pajek (see Figure 3). Clearly, there are many different metrics that could be used to assess such networks. The most obvious of these is using the number of linkages between the nodes or closure, thereby measuring the cohesiveness of the network, in order to assess whether it is more or less tightly connected than would occur using random data. Another measure is the notion of the strength of the ties: if A has co-authored work with B and also with C, then there must be linkages between A and B and also between A and C. However, if A has written five papers with B but only one with C, then clearly the strength of the tie between A and B is greater than that with C within the CASCON network. These and other issues are discussed in more detail below, and will allow us to address the research questions identified above.

4 Results

Building from the SNA framework, we develop an understanding of the structure of the CASCON community – is this network highly clustered around a few individuals, or is it a more random set of connections? Is there a centre around which, or from which, knowledge (and hence we might hypothesize, research strategy), is pushed out, or does the structure reflect a more random process?

In performing analyses on social networks, it is often constructive to first use special software programs to draw the network and provide visualizations of the data. Network visualization is considered to be an important tool for providing an intuitive interpretation of the general network structure. The drawing software typically uses nodes (points or vertices) to represent actors in the system and edges (or lines) between the nodes to represent the relations among the actors. In essence, a network picture is simply a graphical representation of the ties and actors that are under investigation.

Upon initial inspection of Figure 3, it is clear there are a number of authors who are isolates or outliers from a larger connected main network; some who have never co-authored (which appear as a single node with no ties to any other nodes) and some who have co-authored with others but collectively are not tied to the larger connected network group (and so appear as smaller groups of nodes tied together but not tied to the larger network group).

![Figure 3: The CASCON co-authorship network between the years 1991-2009](image-url)
While this information is interesting in and of itself, it is also useful to consider how the co-authorship patterns can be further evaluated for understanding the CASCON community development.

The development of the CASCON community from 1991 through 2009 is shown in Figure 4. The size of the network is given by the number of actors, in this case the number of individuals who have been involved in authoring papers for the CASCON conference each year. The CASCON network is not fully connected, in that it contains a number of subsets for which there are no paths between authors in one subset and authors in another subset.

Formally, a component of a network is a maximal connected subgraph; that is, there is a path between all authors in the subgraph (all authors are reachable -- connected) and there is no path between an author in the component and any author not in the component (maximal) [28]. Of these subgraphs, the main component is the component with the largest number of actors. By 2009, there are 1101 actors (authors) in the CASCON network, of which 167 are members of the main component. The changes in the main component size over the years is shown in Figure 4 the proportion of the main component to the entire network is also given, as well as the its diameter (see Appendix 1 for the a detailed review of CASCON network figures between 1991-2009).

The diameter of the network is the length of the longest shortest path between any pairs of nodes in a graph [28]. The diameter is an interesting measure since it gives an idea of how long it would take for a communication to pass through the network.

Density is concerned with the number of connections between nodes in the network. If there are no connections between any of the nodes in a network then density is zero. If each node is connected to every other node (the graph is fully connected) then the density is one. Thus, density ranges between 0 and 1, although in practice the extremes are unlikely to occur, particularly as the network gets larger.

Structural holes represent non-redundant relationships between contacts [7]. To be effective an actor should distinguish primary contacts from secondary (indirect) contacts and then focus attention on primary contacts as ‘ports of access to clusters of people beyond’ [7, p.21]. To be powerful, the actor should focus on maintaining non-redundant primary contacts – contacts who provide access to new clusters – rather than relationships with contacts who duplicate access to existing clusters. The strategy for the actor is to focus resources and attention on maintaining non-redundant primary contacts while maintenance of the total network is delegated to primary contacts in the network (the actor’s secondary contacts will be looked after by the actor’s primary contacts). Each author’s network structure (n=1101) was analyzed based upon the measure of structural holes. The average structural holes ratio for the CASCON community, as well as its changes over the years are presented in Figure 5.

The structural holes ratios are compared to the density measures in Figure 5. We can see that over the years, the structural holes ratio has decreased, whereas the density (cohesion) measures have gradually increased.
When comparing the initial state of the CASCON community, to its current one (see Table 2), we can see that, alongside the growth in the number of actors and the number in the main component, there is also an impressive growth in the density of the main component (from .361 to .623). The increase in the density of the main component and the decrease in its diameter length, which can serve as additional support for the cohesive (i.e. closure) nature of the network [12], alongside the decrease in the structural holes ratio implies on a unique co-authorship pattern. More authors are connected to one another and the connections between them are more redundant. This pattern will be further discussed in the following section.

5. Discussion

In this paper SNA has been used to analyze the research paper co-authorship within the CASCON community. SNA provides a structural view of the networks as entities together with analysis of individual actors and their place in the network. These analyses provide a basis for thinking about how the CASCON community is organized and how social capital evolves within this community.

According to the social capital literature, structural holes have the potential to play an important role in establishing social capital among researchers. Other arguments suggest that the closure of a network creates social capital for all actors in that network. Our analysis indicates that the CASCON community social capital is maintained by the cohesion (closure) that exists among its members. Our analysis also shows that while the average structural holes ratio in the CASCON community has decreased between 1991 and 2009, the cohesion of the network has increased.

It is interesting to note that Hite et al. [15] have shown that in co-authorship networks, the academic scholars in networks with high levels of structural holes outperformed the scholars found in a more cohesive group (i.e. one with more closure). The relationship of interest in that study was between the efficiency of the co-authorship network, and the total number of publications that were published by the members of that network. Hite et al. define an efficient network as one that demonstrates high levels of structural holes, meaning a network in which high numbers of individual actors (i.e. authors) are connected to two other actors who are not connected to each other.

One potential explanation for the fact that the CASCON authorship does not exhibit an increase in structural holes is because of the difference in the samples. Hite et al. focused on top academic journals in the field of research and scholarship on higher education. This network is far more extensive (more actors are involved) thus cohesiveness can be very hard to achieve. It may also be that because the CASCON community first emerged from the CAS community of collaborative research, there is a larger amount of cohesion within the community. Furthermore, it is also important to note that the majority of the authors presenting their work at CASCON come from the same country (Canada), and that there is a large number of authors that repeatedly present papers at CASCON. Those aspects might contribute to the cohesiveness in the CASCON community.

While the CASCON researchers may not have consciously or strategically approached the development of their co-authorship networks, the combination of their co-author relationships created a network structure that has unique characteristics.

<table>
<thead>
<tr>
<th>Year</th>
<th>No. actors in network</th>
<th>No. actors in main component</th>
<th>% actors in main component</th>
<th>Density of main component</th>
<th>Diameter of main component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>87</td>
<td>12</td>
<td>13.8</td>
<td>.361</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 2: Comparing CASCON initial network to current one.

Given that CASCON researchers may not have been aware that their individual co-authorship choices actually aggregated into a larger co-authorship network structure, an opportunity exists to facilitate a more measured and strategic approach to research co-authorship in the future. Here are two notions we would like to bring forward in that context:

Firstly, Burt [9] states that: “my summary conclusion is that while brokerage across structural holes is the source of added value, closure...
[density] can be critical to realizing the value buried in the structural holes”. Since in the case of CASCON we didn’t measure brokerage across structural holes as a source for social capital, the CASCON community might wish to further explore the notion of brokerage across structural holes to examine links between the CASCON network and actors in other networks (e.g. other research communities). If we will expand our analysis to explore the patterns of new members of the CASCON community (authors who presented their paper at CASCON for the first time) and map the users they co-authored with we could gain insights regarding the way new members are joining the CASCON community, and potentially encourage such collaborations (e.g. emphasizing the importance of collaboration between CASCON new members and their more experienced peers through the conference vision and/or the call for papers process).

Furthermore, since density has been found to be a mechanism for maintaining the CASCON social capital, activities that help achieve and sustain density should be encouraged. Vidgen, et al. [26], in their study of co-author networks, point to several activities that might be helpful in that context. For example, Ph.D. students seem to play an important role in co-authorship through publications with their supervisors.

We know\(^2\) that one of the goals of CAS and CASCON is to encourage Ph.D. students to submit papers to CASCON. Each CAS-supported Ph.D. student is expected to submit a paper and a “Best Student Paper” award is presented annually. Thus, we offer that Ph.D. students should continue to be encouraged to submit papers to CASCON. Mechanisms such as a CASCON doctoral consortium should be considered as these provide a meeting place for Ph.D. students and can contribute to future collaboration among them.

Along side this doctoral consortium; we believe that the CASCON acceptance rate should be aligned with the goal of attracting more Ph.D. students’ paper submissions. When looking at the broader picture we need to understand that one of the problems facing current Ph.D. students (in the software engineering and computing fields) is that the field has been growing, but the publication venues have not [25]. This means it is becoming increasingly competitive to get a paper accepted to one of these venues (in some of those venues the acceptance rate can be as low as 10%). Due to this trend, some Ph.D. students simply do not submit their papers to highly competitive conferences. Thus, CASCON can position itself as a venue that will offer Ph.D. students an attractive publication venue. A venue that will offer both a accessible venue for publishing one’s work, while also offering a CV-worthy ACM publication.

Looking at the CASCON acceptance rate for the last 5 years (see table 3) we can learn that during that timeframe, the CASCON acceptance rate was in the range of 25%-30%. We believe that this acceptance rate can serve as a driving force that will attract more Ph.D. student submissions to CASCON.

It is clear that paper quality varies over time, and it seems unlikely that any specific target for acceptance rates makes sense for a given conference in a given year. But we think that the CASCON program committee should consider the acceptance rate as yet another mechanism that can help foster its community as a whole, and specifically the Ph.D. students within this community.

<table>
<thead>
<tr>
<th>Year</th>
<th># of papers submitted to CASCON</th>
<th># of papers accepted to CASCON</th>
<th>Acceptance rate</th>
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<tbody>
<tr>
<td>2005</td>
<td>88</td>
<td>24</td>
<td>27.27</td>
</tr>
<tr>
<td>2006</td>
<td>90</td>
<td>24</td>
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</tr>
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<td>88</td>
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</tr>
<tr>
<td>2010</td>
<td>90</td>
<td>24</td>
<td>26.67</td>
</tr>
</tbody>
</table>

Table 3: CASCON papers acceptance rate over the years\(^3\).

\(^2\) Co-author Kelly Lyons was Director of CAS from 2004 to 2007 and has been a PC member of CASCON from many years.

\(^3\) Statistics obtained from hardcopy versions of the Proceedings.
6. Conclusion

The questions addressed in this paper beg further research given that the results from this study are limited to the population of CASCON. Furthermore, the SNA presented in this paper is not without limitations; the chief one would be only looking at one kind of relationship, co-authoring.

Further research can extend our understanding of the evolution of the CASCON community (and similar co-authored networks). Interviews might prove to be an appropriate way to gain such insights. By interviewing central actors in the network we can better understand the context for collaborative relationships and the participants’ own accounts of the interactions in which they have been involved. Such data can complement the data we currently have and provide us with further insights on how to promote a cohesive co-authoring community. The kinds of questions that can be answered through these interviews include: how are initial contacts between co-authors established and maintained? And, what leads to a connection between two subgraphs in a network?

In research environments, generally, collaborative relationships are quite possibly motivated by a direct need to generate research and publications [13]. To that end, if researchers were empowered with the knowledge of what type of co-authorship relationships to pursue, they may be able to successfully develop an even more effective pathway to increasing the effectiveness of their research work. Thus by extending the scope of evaluation and looking at research performance along side the co-authorship network structure, we have the potential to not only further develop different venues that publish co-authored papers, but also develop a more efficient generalizable strategy for researchers, providing them with insights regarding what types of co-authorship relationships to pursue if they wish to succeed in their work.

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### Appendix A: CASCON SNA detailed results:

<table>
<thead>
<tr>
<th>Year</th>
<th>No. actors in network</th>
<th>No. actors in main component</th>
<th>% actors in main component</th>
<th>Density of main component</th>
<th>Diameter of main component</th>
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<td>.361</td>
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<td>.309</td>
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<td>16.9</td>
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<td>7</td>
<td>17.1</td>
<td>.498</td>
<td>3</td>
</tr>
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