

Neo4j Assignment

Course: Mining Big Datasets 2023

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INSTRUCTIONS

You are given a subset of the high energy physics theory citation network, which contains authors, articles, journals and citations between articles. In particular, the dataset contains 29555 articles with id, title, year and abstract, 15420 authors with names, 836 journals with names and 352807 citations among papers. You can download the dataset (Citation Dataset) from Moodle in csv format.

Property graph model

You are asked to model the data as a property graph by designing the appropriate entities and assigning the relevant labels, types and properties. For your modeling, you need to study the details of all the files that describe the citation network and represent accordingly all attributes as properties on nodes and edges of a graph. In your model you should include only the attributes that describe each node and edge type, without repetitions of elements (e.g., same property being displayed on both a node and an edge). Finally, nodes should not be connected when this is not required by the model.

Importing the dataset into Neo4j

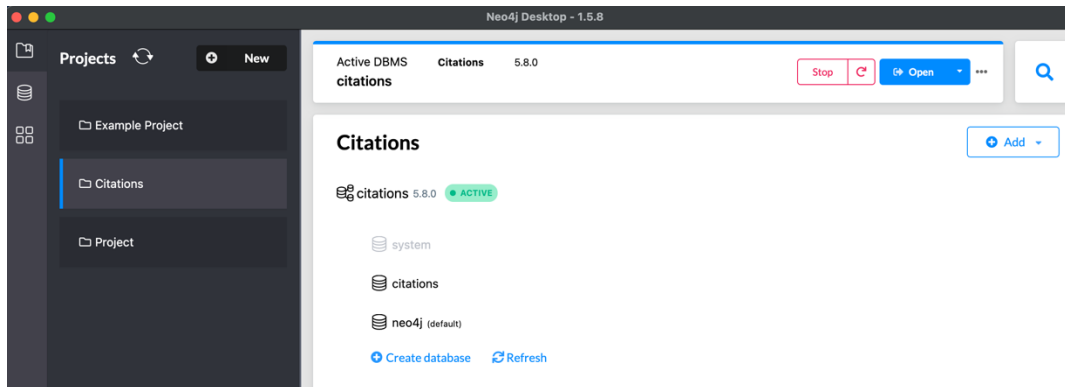
Based on your model, you should create a graph database on Neo4j and load the citation network elements (nodes, edges, attributes). You can load the dataset directly from the provided csv files, by using either the neo4j browser or the neo4j import tool, or any programming language that is supported by neo4j. To speed up loading and query response times, you could also create proper indexes on your model properties.

Querying the database

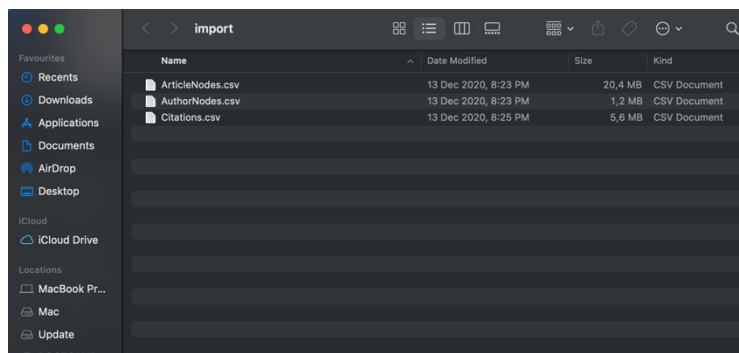
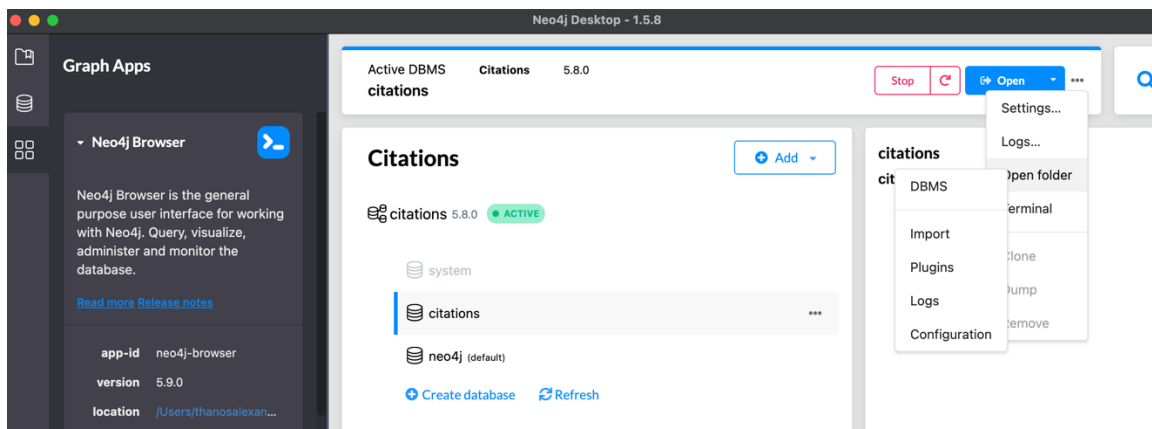
After the creation of your database, you are asked to write and execute queries using the Cypher language.

Property graph model

The first task is to model the data as a property graph by designing the appropriate entities and relationships, assigning the relevant labels, types and properties. To do so and by using the “Neo4j Desktop” edition, we first created a new Project called “Citations” along with a new database.



To be able to retrieve the appropriate data to build the network database, we imported the CSVs in the respective folder, as shown in the following images:



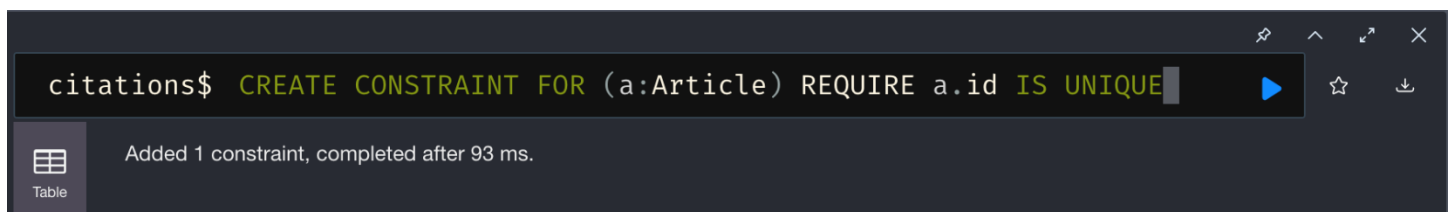
Importing the dataset into Neo4j

Before importing the dataset, we had to understand the data. Inspecting the csv files, we noticed that only the “Citations.csv” had as a special delimiter the “tab” while the rest 2 files (“ArticlesNodes.csv” and “AuthorNodes.csv”) had no special delimiter. The “ArticlesNodes.csv” though, seemed to have “NULL” values in the year, journal and abstract column.

By using the Neo4j Browser we wrote the appropriate Cypher commands to create the network’s nodes and relationships.

The database construction began with the creation of nodes “Articles” which were stored in the “ArticleNodes.csv”.

First, we created a constraint to avoid duplicates and thus every article node to have a unique id.



```

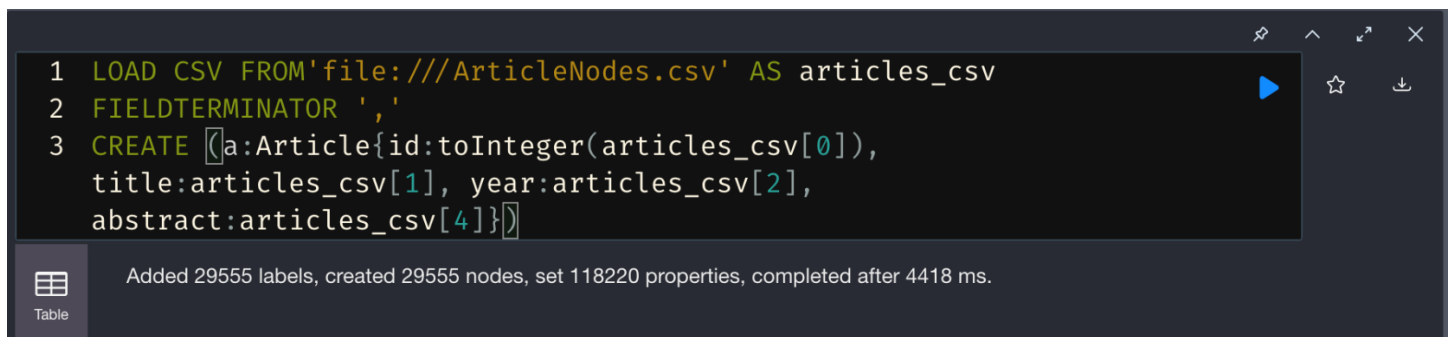
citations$ CREATE CONSTRAINT FOR (a:Article) REQUIRE a.id IS UNIQUE

```

Added 1 constraint, completed after 93 ms.

Then, we loaded the csv file using the **LOAD CSV** clause, to assign the row data to the “articles_csv” variable, and then an “Article” node for each row in the csv was created by using the **CREATE** clause. Every article node had as attribute an “id” (first column of the csv), a “title” (second column), the “year” the article was written (third column) and an “abstract” (fifth column). We did not load data from the “Journal” column as this had been used to create the “Journal” nodes. The field denominator of the file was “,”.

The number of “Article” nodes created was 29555.



```

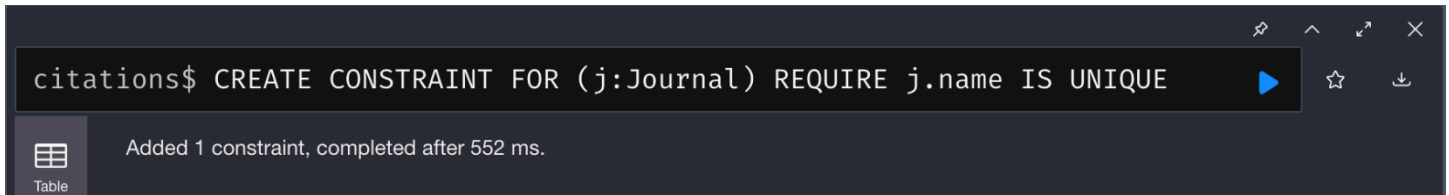
1 LOAD CSV FROM'file:///ArticleNodes.csv' AS articles_csv
2 FIELDTERMINATOR ','
3 CREATE [(a:Article{id:toInteger(articles_csv[0]),
  title:articles_csv[1], year:articles_csv[2],
  abstract:articles_csv[4]})]

```

Added 29555 labels, created 29555 nodes, set 118220 properties, completed after 4418 ms.

Next step was to create the “Journal” nodes.

In order to avoid duplicates again, we set a constraint, so that every journal node had a unique id.



```
citations$ CREATE CONSTRAINT FOR (j:Journal) REQUIRE j.name IS UNIQUE
```

Added 1 constraint, completed after 552 ms.

Table

Similarly, as with the article nodes, we loaded the csv file using the **LOAD CSV** clause, to assign the row data to the “articles_csv” variable. Then a journal node was created for each row that had no null value in the third column (name of journal) in the csv using the **MERGE** clause. Every journal node matched an “Article” node id.

The number of “Journal” nodes created was 836.



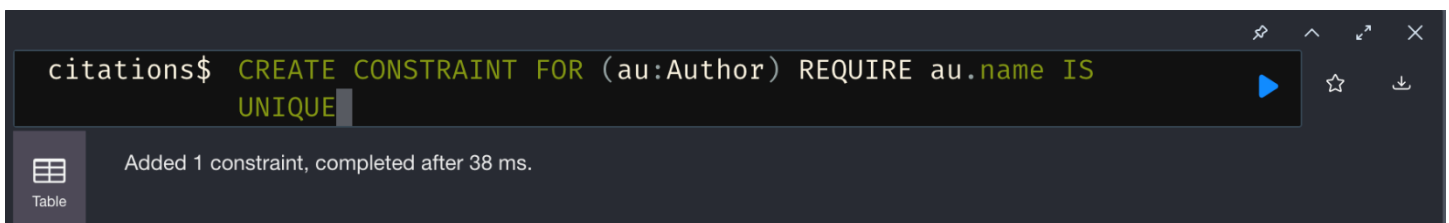
```
1 LOAD CSV FROM 'file:///ArticleNodes.csv' AS articles_csv
2 FIELDTERMINATOR ','
3 WITH articles_csv
4 WHERE articles_csv[3] IS NOT NULL
5 MERGE (j:Journal{name: articles_csv[3]})
6 ON MATCH SET j.id=toInteger(articles_csv[0])
```

Added 836 labels, created 836 nodes, set 21022 properties, completed after 765 ms.

Table

Continuing with the importing process, we proceeded with the creation of the “Authors” nodes.

Following the same logic as before, we set a constraint so that each author had a unique id.



```
citations$ CREATE CONSTRAINT FOR (au:Author) REQUIRE au.name IS UNIQUE
```

Added 1 constraint, completed after 38 ms.

Table

Then we loaded the csv file using the **LOAD CSV** clause, to assign the row data to the authors_csv variable, while an “Author” node was created for each row with the name property set to the value from the second column (authors_csv[1]).

The number of Author nodes created was 15420.

```
1 LOAD CSV FROM 'file:///AuthorNodes.csv' AS authors_csv
2 FIELDTERMINATOR ','
3 MERGE (au:Author{name:authors_csv[1]})
4 ON MATCH SET au.id=toInteger([authors_csv[0]])
```

Added 15420 labels, created 15420 nodes, set 58340 properties, completed after 1331 ms.

After importing the files and creating the network nodes, we created the relationships between the nodes by writing the following queries:

The first relationship was **[PUBLISHED_IN]**, which was created with the **CREATE** command and represented an edge starting from an article and pointing in a journal. To do so, we used the **MATCH** command which took the “Article” and “Journal” fields from the “ArticleNodes.csv” and then created the relationship for each Article.id that had a Journal name. This was done by the **WHERE**, **AND** commands as can be seen in the following picture.

```
1 LOAD CSV FROM "file:///ArticleNodes.csv" AS articles_csv
2 MATCH (a:Article), (j:Journal)
3 WHERE a.id = toInteger(articles_csv[0]) AND j.name =
  articles_csv[3]
4 CREATE (a) - [r:PUBLISHED_IN] -> (j)
```

Created 21022 relationships, completed after 1781 ms.

The second relationship was the **[WRITTEN_BY]** which was created with the **MERGE** command and represented an edge starting from an article and pointing at an author. Compared to the previous query, we used the **MERGE** command as the “Authors” were imported by a different csv (AuthorNodes.csv) and we had to combine the nodes with the already existed “Article” nodes. The **MATCH** commands selected the article and author nodes respectively before merging them.

```
1 LOAD CSV FROM "file:///AuthorNodes.csv" AS author_csv
2 FIELDTERMINATOR ','
3 MATCH (a:Article {id: toInteger(author_csv[0])})
4 MATCH (au:Author {name: author_csv[1]})
5 MERGE (a)-[:WRITTEN_BY]->(au)
```

Created 58340 relationships, completed after 2541 ms.

Finally, we created the **[CITES]** relationship which was also created with the **MERGE** command and represented an edge starting from one article and pointing at another article. Since the edges were stored in the csv file in one cell with “tab” as separator, we used the **FIELDTERMINATOR** command to load the file appropriately. Then with the **MATCH** command we picked the first and second article from the first and second column (index positions 0 and 1). Eventually, we created the relationship by using the **MERGE** function instead of the **CREATE** since the “Articles” nodes were already existent and the edge was imported from the “Citations.csv” file.

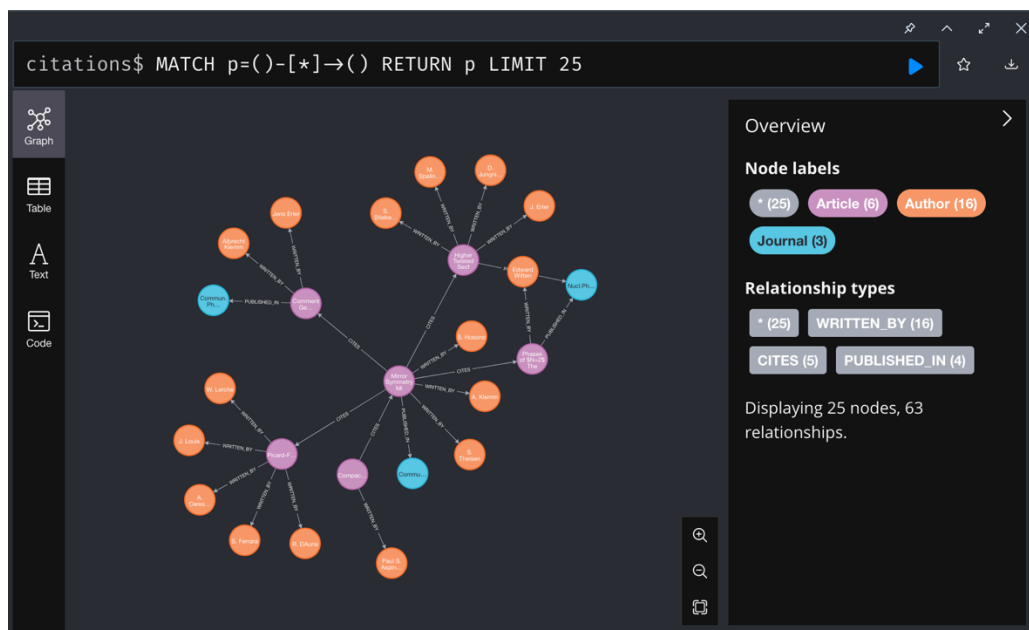
```

1 LOAD CSV FROM "file:///Citations.csv" AS citations
2 FIELDTERMINATOR '\t'
3 MATCH (a1:Article {id: toInteger(citations[0])})
4 MATCH (a2:Article {id: toInteger(citations[1])})
5 MERGE (a1)-[:CITES]-(a2)

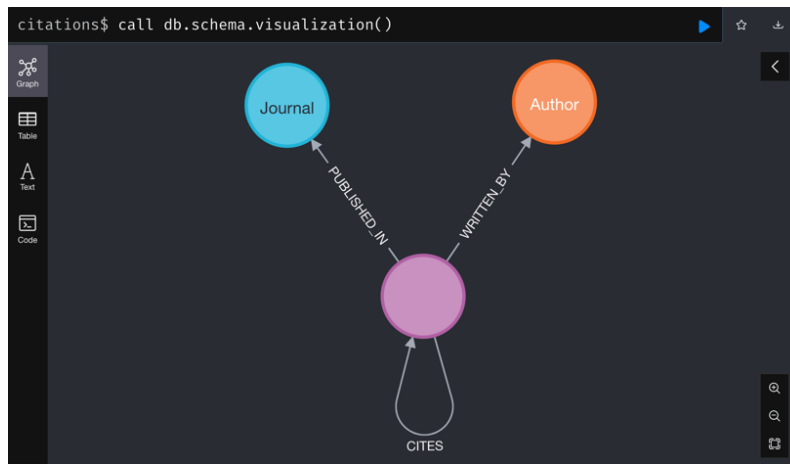
```

Created 352807 relationships, completed after 10622 ms.

Finalizing the construction of the graph database we executed the following query, to have a view of a subgraph of the database consisting of 25 nodes and 63 relationships.



Lastly, the Figure below presents the network graph model, depicting all nodes along with the respective relationship types.



Querying the database

After the successful creation of the database along with the network, we answered the following questions by writing the respective Cypher queries. Below each question there is a picture of the Code with the respective output, as well as an explanation of it.

1 - Which are the top 5 authors with the most citations (from other papers). Return author names and number of citations.

```

1 MATCH (a1:Article)-[r:CITES]->(a2:Article)-[:WRITTEN_BY]->
  (au:Author)
2 RETURN au.name AS Author_name, COUNT(r) AS Number_of_Citations
3 ORDER BY Number_of_Citations DESC
4 LIMIT 5

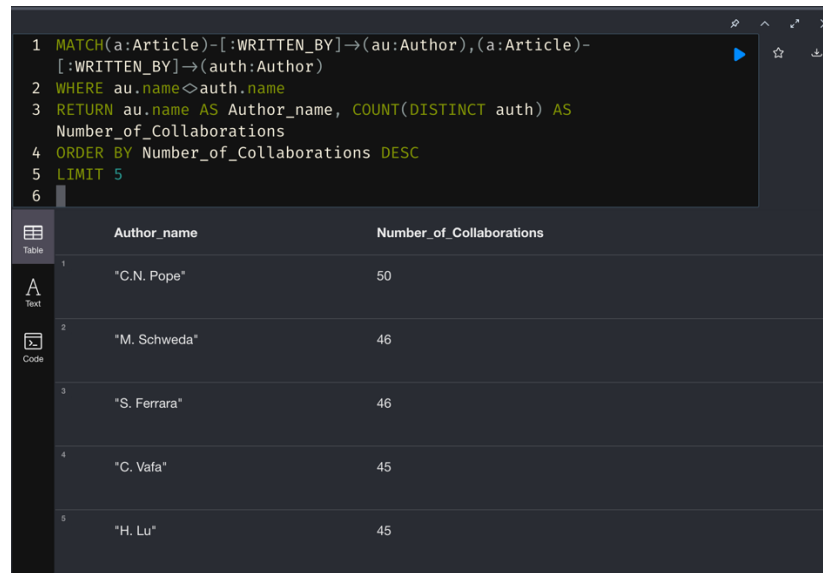
```

	Author_name	Number_of_Citations
1	"Edward Witten"	15681
2	"Ashoke Sen"	7120
3	"Michael R. Douglas"	5577
4	"A.A. Tseytlin"	5288
5	"Joseph Polchinski"	5267

Started streaming 5 records after 1 ms and completed after 556 ms.

First we matched a chain of relationships starting from an article that cited another article (**a1-[r:CITES]->a2**) followed by the **[WRITTEN_BY]** relationship to the corresponding author (**a2-[WRITTEN_BY]->au**). This returned the author's name and the count of citations they had received, ordering the result by the number of citations in descending order, and limiting the result to the top 5 authors.

2 - Which are the top 5 authors with the most collaborations (with different authors). Return author names and number of collaborations.

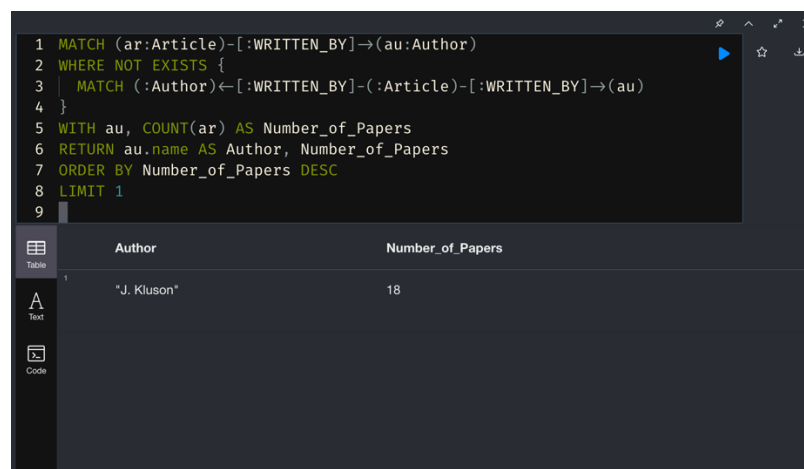


```
1 MATCH(a:Article)-[:WRITTEN_BY]->(au:Author),(a:Article)-
  [:WRITTEN_BY]->(auth:Author)
2 WHERE au.name<>auth.name
3 RETURN au.name AS Author_name, COUNT(DISTINCT auth) AS
  Number_of_Collaborations
4 ORDER BY Number_of_Collaborations DESC
5 LIMIT 5
6
```

	Author_name	Number_of_Collaborations
1	"C.N. Pope"	50
2	"M. Schweda"	46
3	"S. Ferrara"	46
4	"C. Vafa"	45
5	"H. Lu"	45

Similarly in this query, we matched the relationships where an article was written by an author **((a:Article)-[:WRITTEN_BY]->(au:Author))**, and then we matched another author **((a:Article)-[:WRITTEN_BY]->(auth:Author))**. In the **WHERE** clause we ensured that the two authors were different **(au.name <> auth.name)**. This returned the author's name (au.name) and the count of distinct collaborators **(COUNT(DISTINCT auth))** they have collaborated with, ordering the result by the number of collaborations in descending order, and limiting the result to the top 5 authors.

3 - Which is the author who has written the most papers without collaborations. Return author name and number of papers.



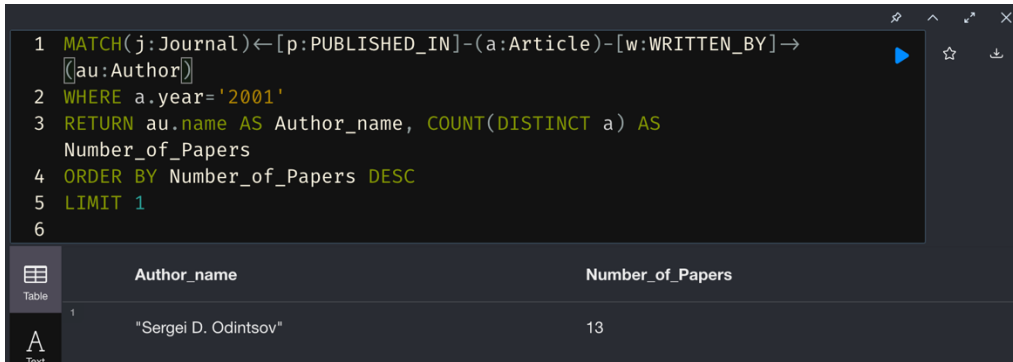
```
1 MATCH (ar:Article)-[:WRITTEN_BY]->(au:Author)
2 WHERE NOT EXISTS {
3   MATCH (:Author)-[:WRITTEN_BY]->(a:Article)-[:WRITTEN_BY]->(au)
4 }
5 WITH au, COUNT(ar) AS Number_of_Papers
6 RETURN au.name AS Author, Number_of_Papers
7 ORDER BY Number_of_Papers DESC
8 LIMIT 1
9
```

	Author	Number_of_Papers
1	"J. Kluson"	18

First we matched the relationships where an article was written by an author **((ar:Article)-[:WRITTEN_BY]->(au:Author))**. Using the **WHERE NOT EXISTS** clause

we checked if there were no collaborations for the author by matching the pattern where another author had written an article that was also written by the target author **((:Author)<-[:WRITTEN_BY]-(:Article)-[:WRITTEN_BY]->(au))**. If no such collaborations existed, then the author and the count of papers they have written **(COUNT(ar))** were included in the result. The result was then ordered by the number of papers in descending order and limited to the top 1 author who had the most papers without collaborations.

4 - Which author published the most papers in 2001? Return author name and number of papers.

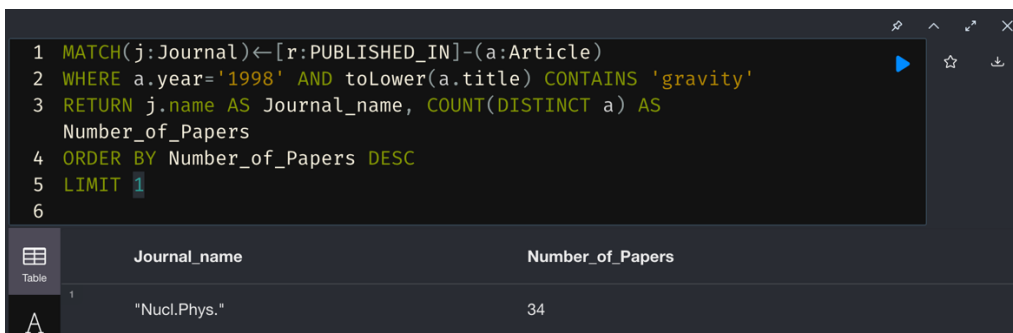


```
1 MATCH(j:Journal)<-[p:PUBLISHED_IN]-(a:Article)-[w:WRITTEN_BY]->
  [au:Author]
2 WHERE a.year='2001'
3 RETURN au.name AS Author_name, COUNT(DISTINCT a) AS
  Number_of_Papers
4 ORDER BY Number_of_Papers DESC
5 LIMIT 1
6
```

	Author_name	Number_of_Papers
1	"Sergei D. Odintsov"	13

We matched the relationships where an article was written by an author **((a:Article)-[w:WRITTEN_BY]->(au:Author))**. The **WHERE** clause filters the articles to only those published in the year 2001 (**a.year = '2001'**). Then, it returns the author's name (**au.name**) and the count of distinct papers they have published **(COUNT(DISTINCT a))**. The result is ordered by the number of papers in descending order and limited to the top 1 author who published the most papers in 2001.

5 - Which is the journal with the most papers about “gravity” (derived only from the paper title) in 1998. Return name of journal and number of papers.



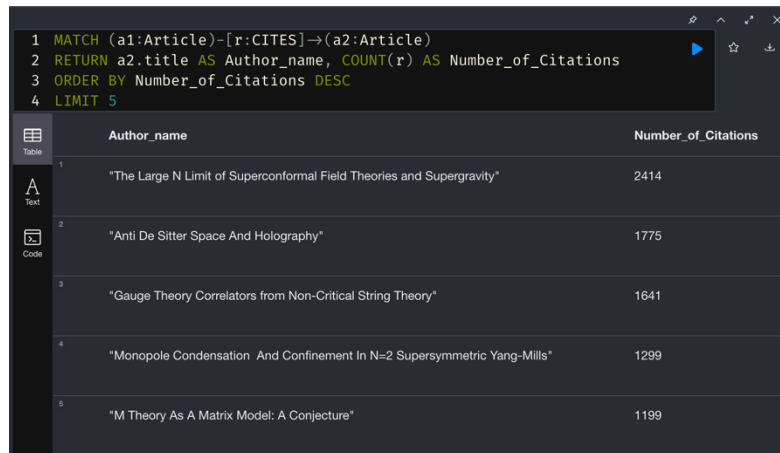
```
1 MATCH(j:Journal)<-[r:PUBLISHED_IN]-(a:Article)
2 WHERE a.year='1998' AND toLower(a.title) CONTAINS 'gravity'
3 RETURN j.name AS Journal_name, COUNT(DISTINCT a) AS
  Number_of_Papers
4 ORDER BY Number_of_Papers DESC
5 LIMIT 1
6
```

	Journal_name	Number_of_Papers
1	"Nucl.Phys."	34

We matched the relationships where an article was published in a journal **((a:Article)-[r:PUBLISHED_IN]->(j:Journal))**. The **WHERE** clause filtered the articles to only those published in the year 1998 and whose title contained the word "gravity". It is important to mention that using the **toLower** function we ensured that words that contained any

capital letters were also included. Then, it returned the journal's name (j.name) and the count of distinct papers published in that journal (**COUNT(DISTINCT a)**). The result was ordered by the number of papers in descending order and limited to the top 1 journal with the most papers about "gravity" in 1998.

6 - Which are the top 5 papers with the most citations? Return paper title and number of citations.



```

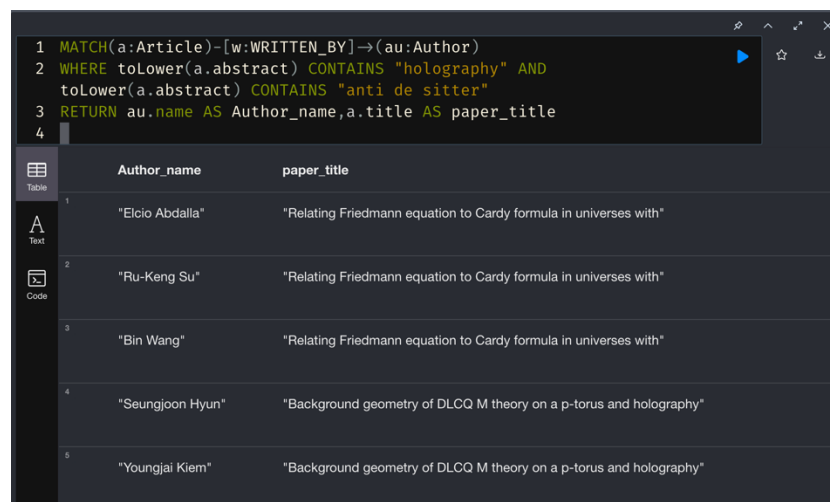
1 MATCH (a1:Article)-[r:CITES]->(a2:Article)
2 RETURN a2.title AS Author_name, COUNT(r) AS Number_of_Citations
3 ORDER BY Number_of_Citations DESC
4 LIMIT 5

```

	Author_name	Number_of_Citations
1	"The Large N Limit of Superconformal Field Theories and Supergravity"	2414
2	"Anti De Sitter Space And Holography"	1775
3	"Gauge Theory Correlators from Non-Critical String Theory"	1641
4	"Monopole Condensation And Confinement In N=2 Supersymmetric Yang-Mills"	1299
5	"M Theory As A Matrix Model: A Conjecture"	1199

Similarly to the first query, this query matched the relationships where one article cited another ((a1:Article)-[r:CITES]->(a2:Article)). It returned the title of the cited paper (a2.title) and the count of citations it has received (**COUNT(r)**). The result was ordered by the number of citations in descending order and limited to the top 5 papers with the most citations.

7 - Which were the papers that use “holography” and “anti de sitter” (derived only from the paper abstract). Return authors and title.



```

1 MATCH(a:Article)-[w:WRITTEN_BY]->(au:Author)
2 WHERE toLower(a.abstract) CONTAINS "holography" AND
   toLower(a.abstract) CONTAINS "anti de sitter"
3 RETURN au.name AS Author_name,a.title AS paper_title
4

```

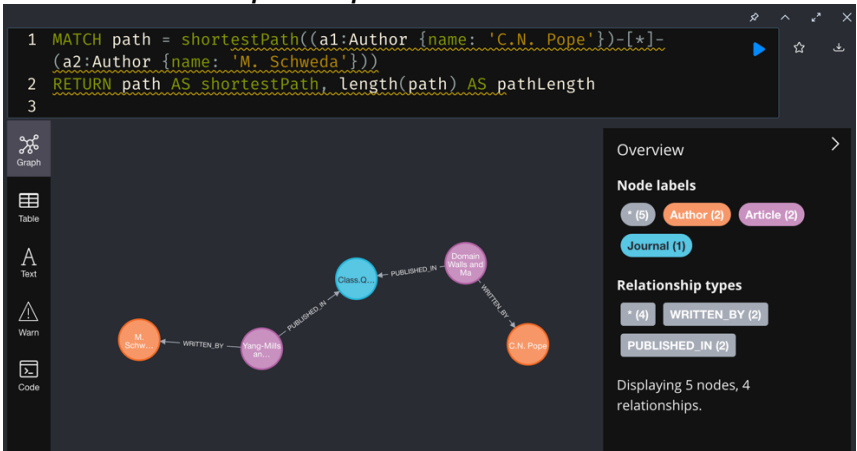
	Author_name	paper_title
1	"Elcio Abdalla"	"Relating Friedmann equation to Cardy formula in universes with"
2	"Ru-Keng Su"	"Relating Friedmann equation to Cardy formula in universes with"
3	"Bin Wang"	"Relating Friedmann equation to Cardy formula in universes with"
4	"Seungjoon Hyun"	"Background geometry of DLCQ M theory on a p-torus and holography"
5	"Youngjai Kiem"	"Background geometry of DLCQ M theory on a p-torus and holography"

This query matched the relationships between articles and authors ((a:Article)-[w:WRITTEN_BY]->(au:Author)). It filtered the articles based on the conditions that the

abstract contained the terms "holography" and "anti de sitter". Once again, we used the **toLower** function in order to include also the words and phrases containing capital letters. This returned the title of the paper (a.title) and the name of the author (au.name) for the matching papers.

8 - Find the shortest path between ‘C.N. Pope’ and ‘M. Schweda’ authors (use any type of edges). Return the path and the length of the path. Comment about the type of nodes and edges of the path.

Graph Represented Path



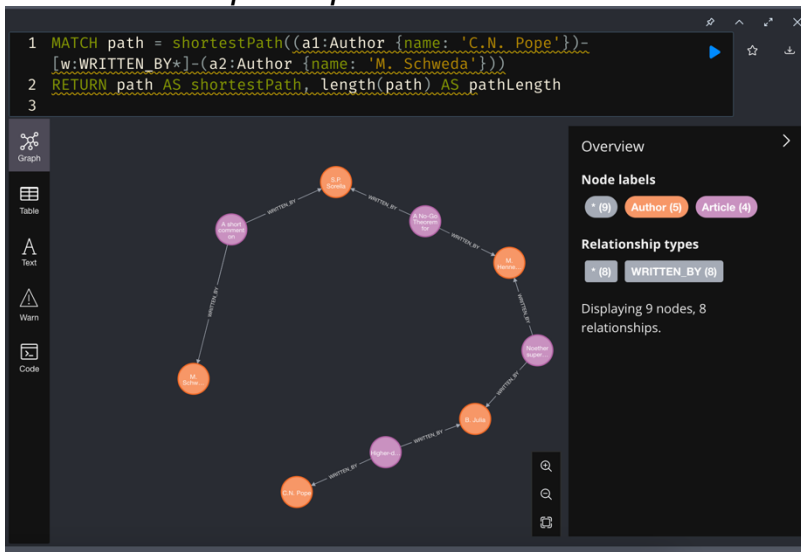
Text Represented Path

shortestPath	pathLength
<pre>{:Author {name: "C.N. Pope",id: 9910252}}<-[:WRITTEN_BY]-(:Article { year: "2000",id: 1002,abstract: " We point out that massive gauged supergravity potentials- for example those arising due to the massive breathing mode of sphere reductions in M-theory or string theory- al low for supersymmetric (static) domain wall solutions which are a hyb rid of a Randall-Sundrum domain wall on one side- and a dilatonic dom ain wall with a run-away dilaton on the other side. On the anti-de S itter (AdS) side- these walls have a repulsive gravity with an asympt otic region corresponding to the Cauchy horizon- while on the other s ide the runaway dilaton approaches the weak coupling regime and a non -singular attractive gravity- with the asymptotic region correspondin g to the boundary of spacetime. We contrast these results with the si tuation for gauged supergravity potentials for massless scalar modes- whose supersymmetric AdS extrema are generically maxima- and there t he asymptotic regime transverse to the wall corresponds to the bounda ry of the AdS spacetime. We also comment on the possibility that the massive breathing mode may- in the case of fundamental domain-wall s ources- stabilize such walls via a Goldberger-Wise mechanism.",title: "Domain Walls and Massive Gauged Supergravity Potentials"})-[:PUBLI SHED_IN]->(:Journal {name: "Class.Quant.Grav.",id: 9912200})<-[:PUBL ISHED_IN]->(:Article {year: "1994",id: 9408030,abstract: " The BRST transformations for the Yang-Mills gauge fields in the presence of gr avity with torsion are discussed by using the so-called Maurer-Carta n horizontality conditions. With the help of an operator \$d_3\$ which a llows to decompose the exterior spacetime derivative as a BRST commut ator we solve the Wess-Zumino consistency condition corresponding to invariant Chern-Simons terms and gauge anomalies.",title: "Yang-Mills gauge anomalies in the presence of gravity with torsion"})-[:WRITTE N_BY]->(:Author {name: "M. Schweda",id: 9911127})</pre>	4

First we used the **shortestPath()** function to find the shortest path between the two specified authors. The **[*]** pattern allowed for any type of relationship in the path. This returned the path itself as **ShortestPath** and the length of the path as **PathLength**.

9 - Run again the previous query (8) but now use only edges between authors and papers. Comment about the type of nodes and edges of the path. Compare the results with query 8.

Graph Represented Path



Text Represented Path

shortestPath	pathLength
<pre>{:Author {name: "C.N. Pope",id: 9910252}}<-[:WRITTEN_BY]-(:Article {year: "1999",id: 9909099,abstract: " It is well known that the toroidal dimensional reduction of supergravities gives rise in three dimensions to theories whose bosonic sectors are described purely in terms of scalar degrees of freedom- which parameterise sigma-model coset spaces. For example- the reduction of eleven-dimensional supergravity gives rise to an E₈/SO(16) coset Lagrangian. In this paper- we dispense with the restrictions of supersymmetry- and study all the three-dimensional scalar sigma models G/H where G is a maximally-non-compact simple group- with H its maximal compact subgroup- and find the highest dimensions from which they can be obtained by Kaluza-Klein reduction. A magic triangle emerges with a duality between rank and dimension. Interesting also are the cases of Hermitean symmetric spaces and quaternionic spaces.",title: "Higher-dimensional Origin of D=3 Coset Symmetries"})-[:WRITTEN_BY]->(:Author {name: "B. Julia",id: 9911035})<-[:WRITTEN_BY]-(:Article {year: "1999",id: 9904003,abstract: " Straightforward application of the standard Noether method in supergravity theories yields an incorrect superpotential for local supersymmetry transformations- which gives only half of the correct supercharge. We show how to derive the correct superpotential through Lagrangian methods- by applying a criterion proposed recently by one of us. We verify the equivalence with the Hamiltonian formalism. It is also indicated why the first-order and second-order formalisms lead to the same superpotential. We rederive in particular the central extension by the magnetic charge of the $\mathcal{N}=2$ algebra of SUGRA asymptotic charges.",title: "Noether superpotentials in supergravities"})-[:WRITTEN_BY]->(:Author {name: "M. Henneaux",id: 9906121})<-[:WRITTEN_BY]-(:Article {year: "1997",id: 9707129,abstract: " We prove that there is no power-counting renormalizable nonabelian generalization of the abelian topological mass mechanism in four dimensions. The argument is based on the technique of consistent deformations of the master equation developed by G. Barnich and one of the authors. Recent attempts involving extra fields are also commented upon.",title: "A No-Go Theorem for the Nonabelian Topological Mass Mechanism in Four dimensions"})-[:WRITTEN_BY]->(:Author {name: "S.P. Sorella",id: 9907073})<-[:WRITTEN_BY]-(:Article {year: "1992",id: 9212112,abstract: " The topological supersymmetry of the pure Chern-Simons model in three dimensions is established in the case where the theory is defined in the axial gauge.",title: "A short comment on the supersymmetric structure of Chern-Simons theory"})-[:WRITTEN_BY]->(:Author {name: "M. Schweda",id: 9911127})</pre>	8

In this query we were asked to use only edges between authors and papers, so we modified our code to specify that we want only the **WRITTEN_BY** relationship to be considered. The **[[:WRITTEN_BY*]]** pattern specified that the path should consist of zero or more **WRITTEN_BY** relationships and no other ones. The rest was the same logic as the previous one.

However, this restriction gave us a path with 8 steps instead of 4 steps that we had in the previous one. As we can see in the results above, since the **PUBLISHED_IN** relationship was not used the Journal nodes were also not included and a different longer shortest path with 8 steps occurred, containing only **WRITTEN_BY** relationships.

10 - Find all authors with shortest path lengths > 25 from author 'Edward Witten'. The shortest paths will be calculated only on edges between authors and articles. Return author name, the length and the paper titles for each path.

```

1 MATCH p = ShortestPath((auth:Author {name:'Edward Witten'})-
  [w:WRITTEN_BY*]-(auth2:Author))
2 WHERE auth <> auth2
3 AND NONE(j IN nodes(p) WHERE j:Journal)
4 WITH auth2, p, length(p) AS Path_Length
5 WHERE Path_Length > 25
6 RETURN auth2.name AS Author_Name, Path_Length,
7 | [n IN nodes(p) WHERE n.title IS NOT NULL | n.title] AS
  Paper_Titles
8 ORDER BY Path_Length DESC
9

```

Author_Name	Path_Length	Paper_Titles
"G.Miele"	30	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "Interaction of d=2 c=1 Discrete States from String Field Theory", "Elliptic Ruijsenaars-Schneider model via the Poisson reduction of the", "On the SO(N) symmetry of the chiral SU(N) Yang-Mills model", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "On Quantum Deformation of the Schwarzschild Solution", "On the Description of the Riemannian Geometry in the Presence of Conical", "Finite-Temperature Scalar Field Theory in Static de Sitter Space"]
"A.I.Zelnikov"	30	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "\$N\$-point amplitudes for d=2 c=1 Discrete States from String Field", "Elliptic Ruijsenaars-Schneider model from the cotangent bundle over the", "Canonical quantization of the degenerate WZ action including chiral", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "On Quantum Deformation of the Schwarzschild Solution", "On One-loop Quantum Corrections to the Thermodynamics of Charged Black", "Black Hole Entropy: Off-Shell vs On-Shell"]
"V.P.Frolov"	28	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "\$N\$-point amplitudes for d=2 c=1 Discrete States from String Field", "Elliptic Ruijsenaars-Schneider model from the cotangent bundle over the", "Canonical quantization of the degenerate WZ action including chiral", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and

		Noninvariant Renormalization", "On Quantum Deformation of the Schwarzschild Solution", "On One-loop Quantum Corrections to the Thermodynamics of Charged Black"]
"W. Israel"	28	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "\$N\$-point amplitudes for d=2 c=1 Discrete States from String Field", "Elliptic Ruijsenaars-Schneider model from the cotangent bundle over the", "Canonical quantization of the degenerate WZ action including chiral", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "On Quantum Deformation of the Schwarzschild Solution", "On One-loop Quantum Corrections to the Thermodynamics of Charged Black"]
"L.V. Avdeev"	28	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "\$N\$-point amplitudes for d=2 c=1 Discrete States from String Field", "Elliptic Ruijsenaars-Schneider model from the cotangent bundle over the", "Canonical quantization of the degenerate WZ action including chiral", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "Antisymmetric tensor matter fields: an abelian model", "A queer reduction of degrees of freedom"]
"D.V.Fursaev"	28	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "Interaction of d=2 c=1 Discrete States from String Field Theory", "Elliptic Ruijsenaars-Schneider model via the Poisson reduction of the", "On the SO(N) symmetry of the chiral SU(N) Yang-Mills model", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "On Quantum Deformation of the Schwarzschild Solution", "On the Description of the Riemannian Geometry in the Presence of Conical"]
"S.N.Solodukhin"	26	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "Interaction of d=2 c=1 Discrete States from String Field Theory", "Elliptic Ruijsenaars-Schneider model via the Poisson reduction of the", "On the SO(N) symmetry of the chiral SU(N) Yang-Mills model", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "On Quantum Deformation of the Schwarzschild Solution"]
"I.N.Kondrashuk"	26	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "Interaction of d=2 c=1 Discrete States from String Field Theory", "Elliptic Ruijsenaars-Schneider model via the Poisson reduction of the", "On the SO(N) symmetry of the chiral SU(N) Yang-Mills model", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "Difficulties of an Infrared Extension of Differential Renormalization"]

"Katsunori Kawamura"	26	["Black Hole Entropy in M-Theory", "N=2 Extremal Black Holes", "Twelve-Dimensional Aspects of Four-Dimensional N=1 Type I Vacua", "Explicit Construction of Yang-Mills Instantons on ALE Spaces", "Non Local Observables and Confinement in BF Formulation of Yang-Mills", "Quantized Temperatures Spectra in Curved Spacetimes", "Correspondence between Minkowski and de Sitter Quantum Field Theory", "Towards a General Theory of Quantized Fields on the Anti-de Sitter", "Towards a Relativistic KMS Condition", "Spontaneous Collapse of Supersymmetry", "Notes on Unfair Papers by Mebarki et al. on ``Quantum Nonsymmetric", "D=26 and Exact Solution to the Conformal-Gauge Two-Dimensional Quantum", "Pseudo Cuntz Algebra and Recursive FP Ghost System in String Theory"]
"M.V.Chizhov"	26	["Supersymmetric Yang-Mills Systems And Integrable Systems", "Non-Perturbative Vacua and Particle Physics in M-Theory", "Wrapped fivebranes and N=2 super Yang-Mills theory", "Holographic Renormalization and Ward Identities with the Hamilton-Jacobi", "Conformal Field Theory Correlators from Classical Scalar Field Theory on", "On Black Hole Creation in Planckian Energy Scattering", "\$N\$-point amplitudes for d=2 c=1 Discrete States from String Field", "Elliptic Ruijsenaars-Schneider model from the cotangent bundle over the", "Canonical quantization of the degenerate WZ action including chiral", "Universal invariant renormalization for supersymmetric theories", "Projective Invariance and One-Loop Effective Action in Affine-Metric", "The Background-Field Method and Noninvariant Renormalization", "Antisymmetric tensor matter fields: an abelian model"]
"R. Casalbuoni"	26	["Evidence for Heterotic/Heterotic Duality", "Quantum discontinuity between zero and infinitesimal graviton mass with", "A New Approach to Axial Vector Model Calculations II", "Photon Splitting in a Strong Magnetic Field: Recalculation and", "Microcanonical Ensemble and Algebra of Conserved Generators for", "Quarks in the Skyrme- t Hooft-Witten Model", "The Dirac-Coulomb Problem for the \$\\kappa\$-Poincare Quantum Group", "Italian workshop on quantum groups", "Exponential mapping for non semisimple quantum groups", "Heisenberg XXZ Model and Quantum Galilei Group", "Quantum Galilei Group as Symmetry of Magnons", "Scalar and spinning particles in a plane wave field", "Thermodynamics of the Massive Gross-Neveu Model"]
"R. Gatto"	26	["Evidence for Heterotic/Heterotic Duality", "Quantum discontinuity between zero and infinitesimal graviton mass with", "A New Approach to Axial Vector Model Calculations II", "Photon Splitting in a Strong Magnetic Field: Recalculation and", "Microcanonical Ensemble and Algebra of Conserved Generators for", "Quarks in the Skyrme- t Hooft-Witten Model", "The Dirac-Coulomb Problem for the \$\\kappa\$-Poincare Quantum Group", "Italian workshop on quantum groups", "Exponential mapping for non semisimple quantum groups", "Heisenberg XXZ Model and Quantum Galilei Group", "Quantum Galilei Group as Symmetry of Magnons", "Scalar and spinning particles in a plane wave field", "Thermodynamics of the Massive Gross-Neveu Model"]
"G. Pettini"	26	["Evidence for Heterotic/Heterotic Duality", "Quantum discontinuity between zero and infinitesimal graviton mass with", "A New Approach to Axial Vector Model Calculations II", "Photon Splitting in a Strong Magnetic Field: Recalculation and", "Microcanonical Ensemble and Algebra of Conserved Generators for", "Quarks in the Skyrme- t Hooft-Witten Model", "The Dirac-Coulomb Problem for the \$\\kappa\$-Poincare Quantum Group", "Italian workshop on quantum groups", "Exponential mapping for non semisimple quantum groups", "Heisenberg XXZ Model and Quantum Galilei Group", "Quantum Galilei Group as Symmetry of Magnons", "Scalar and spinning particles in a plane wave field", "Thermodynamics of the Massive Gross-Neveu Model"]
"M. Modugno"	26	["Evidence for Heterotic/Heterotic Duality", "Quantum discontinuity between zero and infinitesimal graviton mass with", "A New Approach to Axial Vector Model Calculations II", "Photon Splitting in a Strong Magnetic Field: Recalculation and", "Microcanonical Ensemble and Algebra of Conserved Generators for", "Quarks in the Skyrme- t Hooft-Witten Model", "The Dirac-Coulomb Problem for the \$\\kappa\$-Poincare Quantum Group", "Italian workshop on quantum groups", "Exponential mapping for non semisimple quantum groups", "Heisenberg XXZ Model and Quantum Galilei Group", "Quantum Galilei Group as Symmetry of Magnons", "Scalar and spinning particles in a plane wave field", "Thermodynamics of the Massive Gross-Neveu Model"]

First, we defined the variable **p** to represent the shortest path. The **ShortestPath** function found the shortest path between the author 'Edward Witten' and any other author connected through the **WRITTEN_BY** relationship.

Then, we used **WHERE** clause to filter out the case where the starting author was the same as the ending author (auth <> auth2).

Next, we used **NONE** function to ensure that none of the nodes in the path p were of type Journal, ensuring that the path consisted only of authors and articles. The **WITH** clause retained the auth2 author, the path p while calculating the length of the path as **Path_Length**. The second **WHERE** clause filtered out paths with a length of 25 or less.

Finally, we defined the requested properties to be returned and we sorted the results in descending order based on the **Path_Length**.