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Developing a graph-based, domain-specific social network

Master's Thesis

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Hallgatói nyilatkozat

Alulírott **Lucz Tamás Soma** szigorló hallgató kijelentem, hogy ezt a diplomatervet meg nem engedett segítség nélkül, saját magam készítettem, csak a megadott forrásokat (szakirodalom, eszközök stb.) használtam fel. Minden olyan részt, melyet szó szerint, vagy azonos értelemben, de átfogalmazva más forrásból átvettem, egyértelműen, a forrás megadásával megjelöltem.

Hozzájárulok, hogy a jelen munkám alapadatait (szerző(k), cím, angol és magyar nyelvű tartalmi kivonat, készítés éve, konzulens(ek) neve) a BME VIK nyilvánosan hozzáférhető elektronikus formában, a munka teljes szövegét pedig az egyetem belső hálózatán keresztül (vagy hitelesített felhasználók számára) közzétegye. Kijelentem, hogy a benyújtott munka és annak elektronikus verziója megegyezik. Dékáni engedéllyel titkosított diplomatervek esetén a dolgozat szövege csak 3 év eltelte után válik hozzáférhetővé.

Kelt: Budapest, 2020. május 31.

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Lucz Tamás Soma
s.k.

Kivonat Napjaink globalizált világának működésében kulcsfontosságú szerepet tölt be a diplomácia. Diplomatává válni hosszú folyamat, mely korai elhivatottságot kíván – gyakran középiskolás vagy egyetemista korban, világszervezetek munkájának tanulmányi célú szimulációjában való részvétellel kezdődik egy karrier. *Egy* leendő diplomata karrierjét támogatva nemcsak betekintést nyújthatunk az általa is formált közös jövőnkbe, de hosszú távon annak alakításában is részt vehetünk. *Az összes* leendő diplomata karrierjét tekintve a lehetőségek tárháza határtalan, az ezzel járó felelősség pedig hatalmas.

A *Model United Nations (MUN)* keretrendszerben világszerte évente többszázas nagyságrendben megrendezett konferenciákon résztvevő középiskolás és egyetemista diákok az Egyesült Nemzetek Szervezete (ENSZ) mindennapi munkájának formális szimulációján keresztül tanulhatnak diplomáciáról, nemzetközi kapcsolatokról, világpolitikáról – kockázatmentes, tényekre és információkra alapozott vitakultúrát kultiváló környezetben, gyakran tapasztalt karrierdiplomaták támogatásával.

A világ MUN-közösségének összefogására több szoftveres kísérlet is született. Ezek többnyire egy-egy problémára igyekeznek elszigetelt megoldást adni, így kapcsolatépítésre, konferenciák szakmai szervezésére, illetve rendezvények általános adminisztrációjára eltérő – gyakran házon belüli – szoftverek használatosak. Ezen alkalmazások nem kötik össze a közösség egészét, és nem adnak teljes megoldást az adminisztratív problémákra sem.

Dolgozatomban kifejtem, ahogyan megtervezem, lefejlesztem, és webalkalmazásként publikusan elérhetővé teszem a *Diplomatiq* nevű, MUN-konferenciák szervezésére alkalmas közösségi hálózatot. A *Diplomatiq* hosszú távú célkitűzése az, hogy a diplomaták elsődleges közösségi platformjaként nyújtson integrált megoldást az MUN-világban felmerülő adminisztratív problémákra.

A tervezés és fejlesztés teljes folyamata alatt fókuszban tartottam két alapvető szempontot. Az első szempont, hogy a rendszer „használatra kész” minőségben készüljön el, és később igény szerint bővíthető legyen további közösségi, adminisztratív, illetve valós idejű adatelemzési funkcionalitással. Ennek célja, hogy a szoftver a jövőben az MUN-szcénán kívül valódi diplomáciai alkalmazásokban is helyt tudjon állni. A második szempont – a tárolt személyes adatok, illetve a szoftver leendő alkalmazási lehetőségeinek figyelembe vételével – az, hogy a rendszer már a kezdetektől modern, réteges, kriptográfiai biztosítékokat nyújtó biztonsági architektúrára alapozva készüljön el.

A rendszer tervezése és fejlesztése során a mérnöki szempontokon felül arra is figyelmet fordítottam, hogy a *Diplomatiq*, mint majdani vállalkozás az elvégzett munkámra egyszerűen ráépíthető legyen. A szoftver lefejlesztéséhez és publikációjához szükséges előfizetéseket, szolgáltatásokat és rendszereket mind olyan megfontoltsággal választottam ki és integráltam, mintha egy vállalkozást indítanék el. Dolgozatomban az ezzel kapcsolatban felmerülő adminisztratív és pénzügyi teendők mellett a rendszer egy kezdetleges üzleti modelljéről is beszámolok – kisebb terjedelemben, mérnöki diplomatervről lévén szó.

Abstract Diplomacy plays a key role in the operation of today's globalized world. Turning into a diplomat is a long process and involves early dedication — careers often start in high schools or universities, by students taking part in academic simulations of various intergovernmental organizations' work. Supporting *a* prospective diplomat's career not only enables us to peek into the future through them, but in the long run, we can also take part in jointly shaping tomorrow's world. Considering *all* prospective diplomats' careers, the possibilities are endless, and the associated responsibility is immense.

The world of junior diplomats mostly consists of conferences — annually hundreds of them, worldwide — held within the framework of the *Model United Nations (MUN)*. During these events, high school and university students formally simulate the everyday work of the United Nations (UN), which enables them to learn about diplomacy, international relations and world politics — in a risk-free environment, cultivating debates based solely on facts and information. These conferences are often attended by experienced senior diplomats as well, with the goal of supporting and educating the future generation.

There are several software-involved attempts for bringing together the MUN community. Most of these attempts solve one isolated problem of the collective at a time: social networking, organizing the professional part of conferences, and administering the actual events usually involves several different — mostly primitive, in-house — software. These applications neither link the community together, nor do they offer a complete solution to administrative problems.

In this thesis I design, implement and publish *Diplomatiq*, a social network software system for diplomats, suitable for organizing MUN conferences. The long-term goal of *Diplomatiq* is to provide an integrated solution for administrative problems in the MUN world, while being the sole professional networking platform for its diplomat users.

During the whole process of the design and implementation, I focused on two key points. The first point is that the system should be implemented in production-grade quality, and it should be easily extendable with further social, administrative, and real-time data analytics features as needed. The goal of this is to enable the system to cover the needs of real-world diplomatic applications as well, outside the MUN scene. The second point — considering the stored personal information, and the future applications — is that the system should be implemented upon a modern, layered security architecture, which provides cryptographic assurances in terms of application and data security.

Besides engineering aspects, I also paid attention to being able to build *Diplomatiq* as a prospective company upon my work. Subscriptions, services and systems needed for the implementation and publication were chosen and integrated with the same amount of consideration as I was starting company. In this thesis I present the related administrative and financial aspects of this too, as well as a primitive business model — briefly only, this being an engineering thesis.

Chapter 1

Introduction

1.1 Context

Diplomacy is the art and practice of conducting negotiations between nations and nationwide entities [1]. It is a complex system, where involved parties like governments and NGOs[1] engage in formal discussions, aspiring to *peacefully* influence the status quo of international relations along their interests. Parties are represented by selected, often professionally trained career diplomats, forming a diplomatic delegation.

Besides diplomacy, there are other tools for leveraging international relations. This set of tools, tactics and strategies is collectively known as foreign policy, and is usually directed by political leaders [2]. Foreign policy is often collated with diplomacy as a synonym, but the two are not identical. Diplomacy is a key instrument of foreign policy, and foreign policy is a superset of diplomacy. In order to achieve the objectives of a nation, tools of foreign policy can include espionage, threats, sabotages, wars, and other means of violence, as well as diplomacy.

Throughout this thesis, I consider diplomacy as the nonviolent elements of foreign policy: the system, methods and infrastructure of governments and NGOs peacefully interacting with each other, in order to influence international relations along their own objectives. Although most diplomacy materializes in confidence between parties, this thesis exists in the context of publicly conducted diplomacy, more narrowly in the context of the United Nations (UN), which — having 193 sovereign member states — is the largest intergovernmental organization in the world [3].

Being a powerful diplomat requires experience in various fields. Diplomats need strong organizational and leadership skills, as well as proficiency in written and oral communication for efficient negotiations. They must be able to stay rational and decisive in stressful

[1] non-governmental organizations

situations, besides the capacity to quickly process and integrate information into their decisions [4]. These skills can be developed in specialized educational institutes, usually offering graduate programs [5].

Apart from professional programs designed to train already graduated career diplomats, there are other ways to gain diplomatic experience. One of these is taking part in academic simulations of the United Nations' everyday work. For high school and university students, the Model United Nations (MUN) framework[2] offers hundreds of independent conferences annually, worldwide [6]. On these few-day-long events, participants become diplomatic delegates. They are placed in UN-like committees and assigned countries to represent. Assignments are published in advance, along with the topics the committees will discuss. This enables delegates to perform research and develop their positions before the conference, usually staying true to the actual position of their represented country. During the conference, delegates discuss their positions in the committees, conforming to the formalities of the real-world United Nations, like western business attire and the method of moderated formal debate. By the end of the conference, each committee produces a formal, UN-like *resolution*: a document summarizing the results of their debate and formulating measures for resolving the international issues presented to the committee.

1.2 Problem statement and requirements

Since even a medium-sized conference welcomes hundreds of international students, who need housing, meals, conference accessories like badges and placards, topics to debate, merchandise, and afterwork entertainment, an MUN conference is a heavy organizational burden, requiring months of preparation. Most conferences are driven, prepared, implemented, and executed by voluntary, unpaid students of an educational institution — a high school or a university —, as an extracurricular activity, with additional help of their teachers. Professional event planners, IT and data administrators or other experts are usually not involved. Also, the staff rotates relatively fast as organizing students graduate and leave the institution, making it harder to reuse last year's experience.

Although in general conferences are self-sustaining by making use of participation fees, the execution quality of the event depends on the creativity, enthusiasm, and personal experience of the students at the top of the organizational hierarchy, rather than a solid financial basis. This results in the lack of ability to build modern, automated organizational tools, which ultimately causes data management to be cumbersome and insecure — even though the major part of the organizational work is indeed data management and batch processing. A software system offered as a rationally priced service, tailored to the administrative needs of MUN conferences could greatly reduce this organizational burden by providing easy-to-use data management features.

[2] The concept of Model United Nations is detailed in Section 2.1.

Aside from the organizational concerns, MUN conferences provide outstanding networking opportunities to both the participants and the organizers. Participants working themselves towards a diplomatic career can substantially benefit from building global acquaintances among their future colleagues. Experienced career diplomats attending MUN conferences as guests can open doors for prospective diplomats which no education can. Professional networking among future and current diplomats can be supported and facilitated well by a suitable software system.

Inspecting current solutions, there is no software system on the internet, which solves the administrative problems of MUN conferences, while making use of the great networking potential of the MUN framework. Implementing such a system would appreciably further global diplomacy in the long run.

1.3 Objectives and contributions

In this thesis I present *Diplomatiq*, a social network software system for diplomats, suitable for organizing MUN conferences. On the one hand, I will refer as *Diplomatiq* to the software system itself, and on the other hand, to the prospective company conducting the maintenance, marketing and sales operations of the software system. Outside the context of this thesis, the social network is the first step of a long-term plan involving global consumption of public data, for producing real-time diplomatic prognoses and analyses.

My first objective was to design and implement Diplomatiq on a solid, production-grade foundation, with a minimal feature set, which can be extended with further social networking, administrative, and real-time data analytics capabilities as needed. Considering the sensitive personal information stored in the system, the prospective applications of Diplomatiq, and my deep interest in cryptography and computer security, my second objective was to build the system upon a modern, layered security architecture, which provides cryptographic assurances in terms of application and data security.

My contributions include the following:

- I designed, built, secured and paid a company-level production infrastructure for the development, publication and maintenance of Diplomatiq, including several kinds of supportive infrastructure.
- I designed, implemented and published the Diplomatiq social network software system as a client-server application, using graph database technologies.
- I developed several supportive libraries outside the Diplomatiq software along the way. I published the built artefacts of these libraries with documentation, for free use in the open-source community.
- I published the source code of all my contributions as separate open-source projects, centralized under one project organization, called Diplomatiq.

1.4 Structure of this thesis

The thesis is structured as follows.

- *Chapter 2* summarizes the preliminary knowledge needed for a high-level understanding of this thesis. It details the concept of Model United Nations and my personal experience with MUN. It also defines the idea of a social network. Then it introduces graph database technologies, focusing on the property graph data model and the Neo4j graph database.
- *Chapter 3* gives examples for domain-specific social networks, and presents existing software solutions for the MUN community.
- *Chapter 4* describes my approach of building and securing a production-grade infrastructure supporting the development and public operation of Diplomatiq, the social network.
- *Chapter 5* gives an overview about the produced supportive libraries. It unfolds the reasons of their existence, as well as their features and implementation details.
- *Chapter 6* demonstrates the Diplomatiq social network application. It discloses the chosen technologies and client-server architecture, its features and development methods, and implementation details.
- *Chapter 7* reveals the applied cryptographic and other security measures I built into Diplomatiq, in order to protect user and system data from unauthorized access, from the API to the database level.
- *Chapter 8* gives a brief insight into the business considerations of Diplomatiq.
- *Chapter 9* concludes the thesis and presents possible future directions.

Chapter 2

Preliminaries

2.1 The Model United Nations framework

2.1.1 Introduction

2.1.2 History

2.1.3 Academic aspects

2.1.4 Real-world results of the framework

2.1.5 Social networking within Model United Nations

2.1.6 Administration of a Model United Nations conference

2.1.7 Personal experience: Budapest International Model United Nations

2.2 Social networks

2.3 Graph database technologies

2.3.1 The property graph data model

2.3.2 Neo4j

2.3.3 Cypher

2.4 Running example

Chapter 3

Related work

3.1 Domain-specific social networks

3.1.1 LinkedIn

3.1.2 DeviantArt

3.1.3 MeetUp

3.2 Best Delegate

3.3 mymun

Chapter 4

Building and securing a company-level production infrastructure

this is the foundation that we can build upon

security will be all over this chapter

4.1 Naming

4.2 Brand

4.3 Domain names

caa record, emails, security, 2fa, etc

4.4 Certificates

Sectigo, positiveSSL, password-protected, safely stored

4.5 Emails

DMARC + DKIM + SPF

4.6 Source code management

GitHub organization, 2FA, security settings, etc

continuous integration

4.7 CI infrastructure

4.8 Neo4j startup program

Enterprise Edition license

4.9 Serving the application on the internet

4.9.1 Choosing the platform

Azure

4.9.2 Active Directory

4.9.3 Naming conventions

4.9.4 Subscription and support subscription

4.9.5 KeyVault

4.9.6 Networking

4.9.7 DB VM

4.10 Infrastructure security

4.10.1 Identity management

4.10.2 Resource management

4.10.3 Network security

tűzfal, vnet rules, TLS mindenhol

4.10.4 Configuration security

everything from keyvault

Chapter 5

Overview and development of supportive libraries

5.1 project-config

5.2 crypto-random

5.2.1 CI

100SonarQube etc

5.3 convertibles

5.3.1 CI

100SonarQube etc

5.4 resily

5.4.1 CI

100SonarQube etc

5.5 eslint-config-tslib

5.6 eslint-config-angular

Chapter 6

Overview and development of the Diplomatiq application

6.1 Platform objectives, target audience

6.2 Features

6.3 Chosen technologies

6.3.1 On the front end layer

Angular

6.3.2 On the back end layer

Spring Boot

6.3.3 On the database layer

Neo4j

6.3.4 Client-server communication

HTTPS only ofc JSON-RPC API no resources, no REST at all

6.3.5 API documentation

OpenAPI v3

6.4 Developing the front end

components services CI platform with 3 slots

6.5 Developing the back end

CI platform with 3 slots filters controllers engines services repositories utils session handling error handling

Chapter 7

Security of the Diplomatiq application

security.txt

nem adunk ki a userről adatot (hogy létezik-e ilyen mailcímű user, stb)

encrypted db values, key versioning to avoid birthday problem

CORS

authentication why not oauth/openid/standard megoldások?

1. signed requests and authentication 2. session levels 3. SRP 4. cryptography

Chapter 8

Monetization and business model

Chapter 9

Conclusion and future work

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References

[1] Merriam-Webster Dictionary. *Diplomacy*. URL: https://www.merriam-webster.com/dictionary/diplomacy (visited on 05/19/2020).

[2] Encyclopædia Britannica Dictionary. *Foreign policy*. URL: https://www.britannica.com/topic/foreign-policy (visited on 05/19/2020).

[3] United Nations. *Member States*. URL: https://www.un.org/en/member-states/index.html (visited on 05/19/2020).

[4] United States Department of State. *Foreign Service Officer Qualifications*. URL: https://careers.state.gov/work/foreign-service/officer/13-dimensions (visited on 05/19/2020).

[5] United States Department of State. *Key Topics – Foreign Service Institute*. URL: https://www.state.gov/key-topics-foreign-service-institute (visited on 05/19/2020).

[6] mymun GmbH. *Full MUN List*. URL: https://mymun.com/muns/list (visited on 05/19/2020).

Appendix