Predviđanje preraspodele tiketa sistema podrške

Seminarski rad u okviru kursa Mašinsko Učenje
Matematički Fakultet, Beograd

Tatjana Kunić 1084/2022

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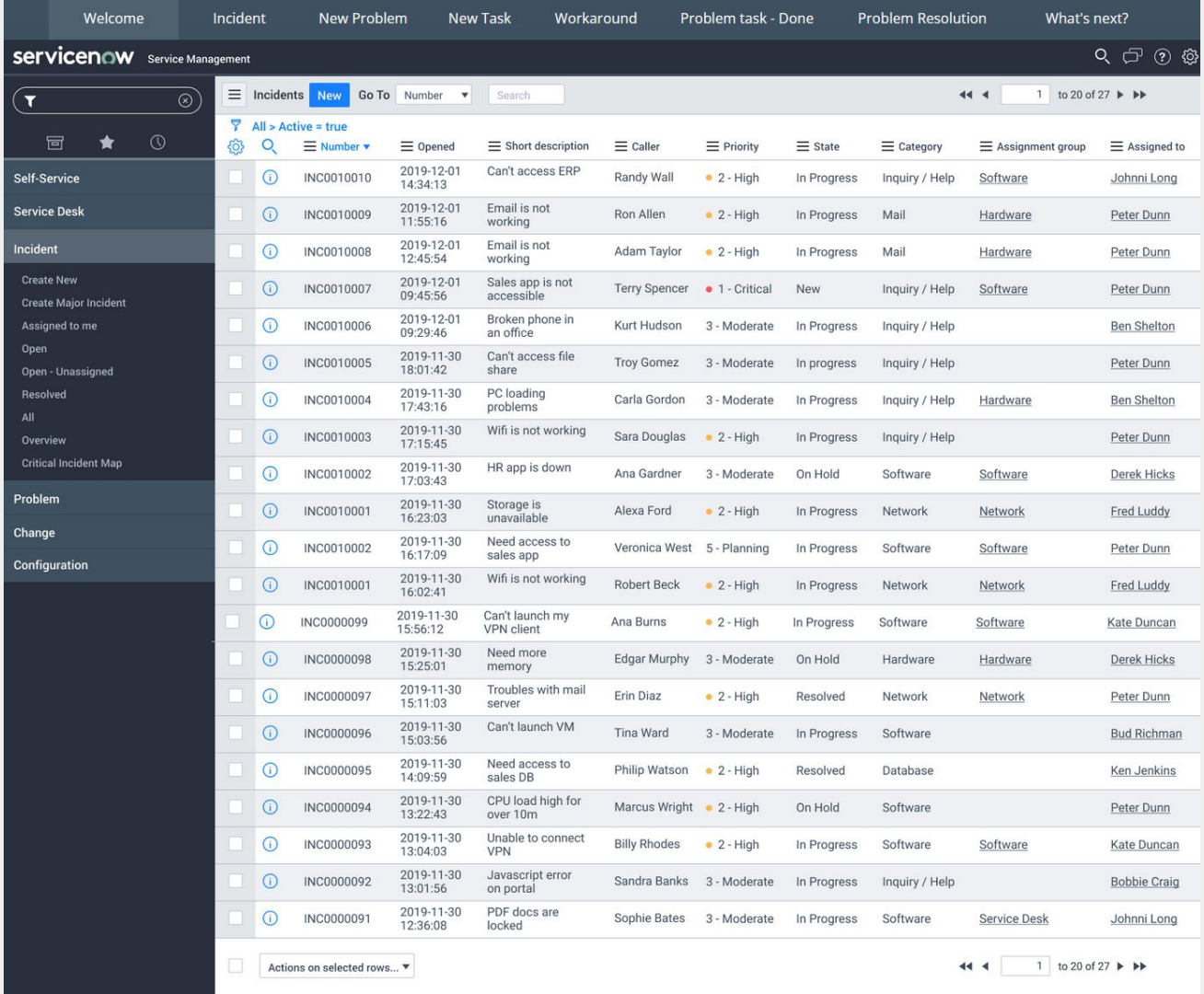
Osnovni pojmovi

- Sistem podrške (eng. help desk) - informacioni sistem za prijavu tehničkih problema softvera
- Korisnici softvera prijavljuju probleme otvaranjem tiketa (eng. ticket)
- Može se desiti da je tiket potrebno ponovo zadužiti (eng. reassign) na neku drugu osobu (ili organizaciju)


Welcome
Incident
New Problem
New Task
Workaround
Problem task - Done
Problem Resolution
What's next?
servicenow
Service Management
Incidents
New
Go To
Number
Search
1
to 20 of 27
All > Active = true
Number
Opened
Short description
Caller
Priority
State
Category
Assignment group
Assigned to
INC0010010 2019-12-01 14:34:13 Can't access ERP Randy Wall 2 - High In Progress Inquiry / Help Software Johnni Long
INC0010009 2019-12-01 11:55:16 Email is not working Ron Allen 2 - High In Progress Mail Hardware Peter Dunn
INC0010008 2019-12-01 12:45:54 Email is not working Adam Taylor 2 - High In Progress Mail Hardware Peter Dunn
INC0010007 2019-12-01 09:45:56 Sales app is not accessible Terry Spencer 1 - Critical New Inquiry / Help Software Peter Dunn
INC0010006 2019-12-01 09:29:46 Broken phone in an office Kurt Hudson 3 - Moderate In Progress Inquiry / Help Ben Shelton
INC0010005 2019-11-30 18:01:42 Can't access file share Troy Gomez 3 - Moderate In progress Inquiry / Help Peter Dunn
INC0010004 2019-11-30 17:43:16 PC loading problems Carla Gordon 3 - Moderate In Progress Inquiry / Help Hardware Ben Shelton
INC0010003 2019-11-30 17:15:45 Wifi is not working Sara Douglas 2 - High In Progress Inquiry / Help Peter Dunn
INC0010002 2019-11-30 17:03:43 HR app is down Ana Gardner 3 - Moderate On Hold Software Software Derek Hicks
INC0010001 2019-11-30 16:23:03 Storage is unavailable Alexa Ford 2 - High In Progress Network Network Fred Luddy
INC0010002 2019-11-30 16:17:09 Need access to sales app Veronica West 5 - Planning In Progress Software Software Peter Dunn
INC0010001 2019-11-30 16:02:41 Wifi is not working Robert Beck 2 - High In Progress Network Network Fred Luddy
INC0000099 2019-11-30 15:56:12 Can't launch my VPN client Ana Burns 2 - High In Progress Software Software Kate Duncan
INC0000098 2019-11-30 15:25:01 Need more memory Edgar Murphy 3 - Moderate On Hold Hardware Hardware Derek Hicks
INC0000097 2019-11-30 15:11:03 Troubles with mail server Erin Diaz 2 - High Resolved Network Network Peter Dunn
INC0000096 2019-11-30 15:03:56 Can't launch VM Tina Ward 3 - Moderate In Progress Software Bud Richman
INC0000095 2019-11-30 14:09:59 Need access to sales DB Philip Watson 2 - High Resolved Database Ken Jenkins
INC0000094 2019-11-30 13:22:43 CPU load high for over 10m Marcus Wright 2 - High On Hold Software Peter Dunn
INC0000093 2019-11-30 13:04:03 Unable to connect VPN Billy Rhodes 2 - High In Progress Software Software Kate Duncan
INC0000092 2019-11-30 13:01:56 Javascript error on portal Sandra Banks 3 - Moderate In Progress Inquiry / Help Bobbie Craig
INC0000091 2019-11-30 12:36:08 PDF docs are locked Sophie Bates 3 - Moderate In Progress Software Service Desk Johnni Long
Actions on selected rows...
1
to 20 of 27
Self-Service
Service Desk
Incident
Create New
Create Major Incident
Assigned to me
Open
Open - Unassigned
Resolved
All
Overview
Critical Incident Map
Problem
Change
Configuration

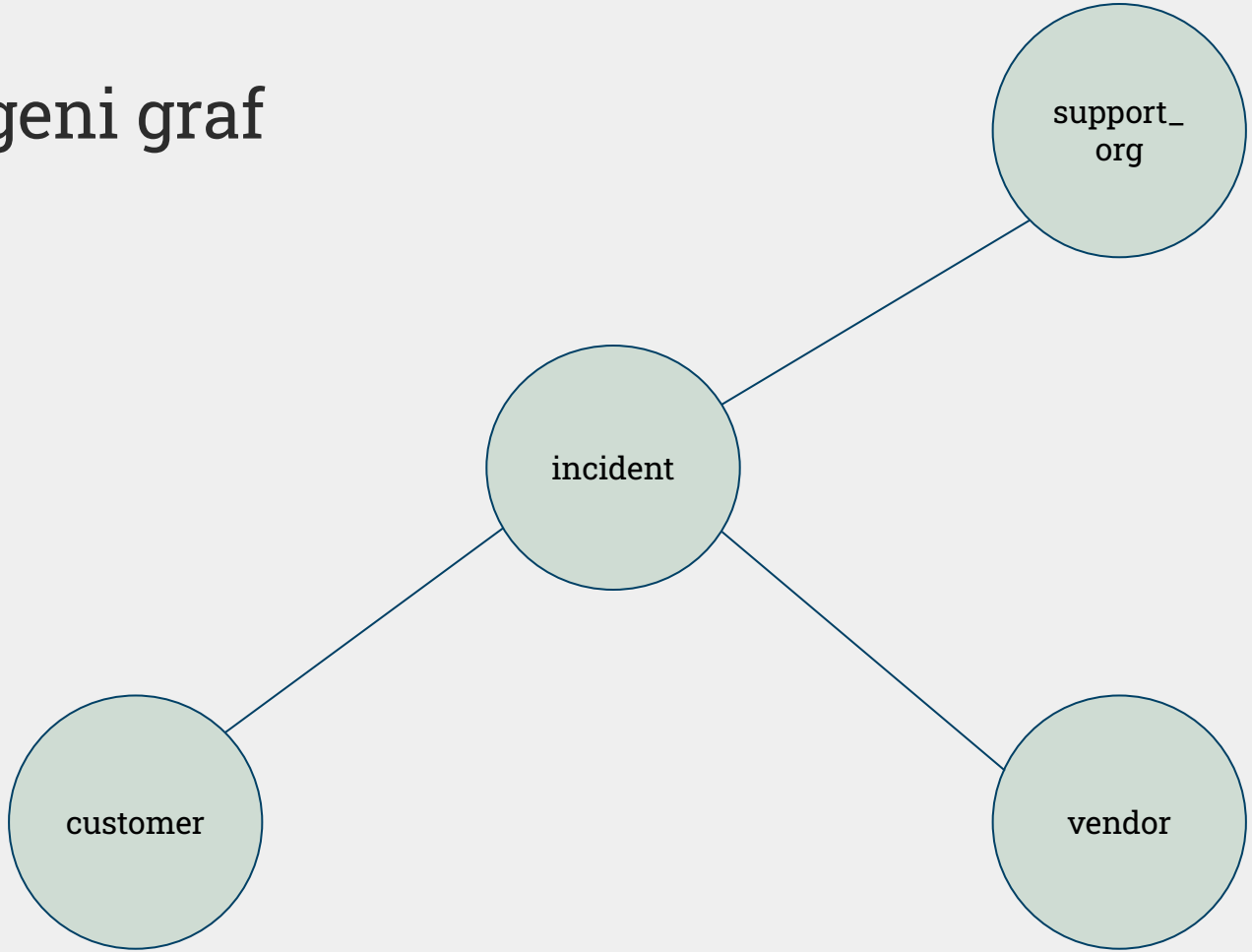
Motivacija

- U interesu svake kompanije je brzo razrešavanje prijavljenih korisničkih problema
- Prebacivanje odgovornosti sa jedne osobe na drugu rezultuje povećanju potrebnog vremena za rešavanje problema, kao i povećanju troškova
- Brza i precizna identifikacija složenosti problema je neophodna

Modelovanje skupa podataka

- Podaci obično predstavljeni u relacionom obliku
- Mnogi upiti nad podacima nisu poznati *apriori*
- Spajanje tabela je računski zahtevna operacija
- Grafovski modeli podataka pokazuju bolje performanse kad je upite potrebno izvršavati *ad hoc**

Heterogeni graf



Atributi

- Svaki čvor ima svoje atribute
- Čvor incident sadrži atribut ***reassigned*** koji indikuje da li je problem prebačen na drugu osobu i on je ciljna promenljiva
- Cilj: Pridružiti čvoru incident klasu 1 ili 0

Grafovske neuronske mreže

- Za čvor u grafa $G = (V, E)$ naredni sloj grafovske neuronske mreže se računa kao: $h_u = Wx_u$

- Više ima smisla posmatrati čvorove u odnosu na svoje susede: $h_u = \sum_{v \in N_u} Wx_v$

- Čvorovi sa većim brojem suseda brže šire informacije kroz mrežu u odnosu na one sa manjim brojem suseda

- Slojevi grafovske konvolutivne mreže za čvor u uključuju i vrstu normalizacije gde se daju veće težine čvorovima sa malim brojem suseda:

$$h_u = \sum_{v \in N_u} \frac{1}{\sqrt{deg(u)}\sqrt{deg(v)}} Wx_v$$

GraphSAGE

- GNN arhitektura koja pokazuje bolje rezultate za velike grafove
- Za svaki čvor koristi se samo podskup skupa suseda unapred određene veličine
- Agregacija slojeva (može biti prosek, LSTM jedinica, *pooling*)

$$h_u^k = \sigma(W \cdot MEAN(\{h_u^{k-1}\} \cup \{h_v^{k-1}, \forall v \in N(u)\}))$$

Učenje na heterogenim grafovima

- Različiti tipovi čvorova imaju različite atribute i dimenzije
- Tokom učenja uzimamo u obzir i relacije među čvorovima
- Želimo umesto pojedinačnih čvorova da posmatramo par čvorova (različitih tipova)
- Neophodan novi sloj neuronske mreže za svaku relaciju

```python
class GCN(torch.nn.Module):
    def __init__(self, hidden_channels, out_channels):
        super().__init__()
        self.conv1 = SAGEConv((-1, -1), hidden_channels[0], aggr='mean')
        self.conv2 = SAGEConv((-1, -1), hidden_channels[1], aggr='mean')
        self.conv3 = SAGEConv((-1, -1), out_channels, aggr='mean')

    def forward(self, x, edge_index):
        x = F.relu(self.conv1(x, edge_index))
        x = F.relu(self.conv2(x, edge_index))
        x = F.softmax(self.conv3(x, edge_index), dim=1)

        return x


gcn = GCN(hidden_channels=[256, 128], out_channels=2)
gcn = to_hetero(gcn, data.metadata(), aggr='sum')
optimizer = torch.optim.Adam(gcn.parameters(), lr=0.001, weight_decay=5e-4)
```

```
GraphModule(
  (conv1): ModuleDict(
    (incident__assigned__support_org): SAGEConv((-1, -1), 256, aggr=mean)
    (incident__assigned__vendor): SAGEConv((-1, -1), 256, aggr=mean)
    (incident__reported__customer): SAGEConv((-1, -1), 256, aggr=mean)
    (support_org__rev_assigned__incident): SAGEConv((-1, -1), 256, aggr=mean)
    (vendor__rev_assigned__incident): SAGEConv((-1, -1), 256, aggr=mean)
    (customer__rev_reported__incident): SAGEConv((-1, -1), 256, aggr=mean)
  )
  (conv2): ModuleDict(
    (incident__assigned__support_org): SAGEConv((-1, -1), 128, aggr=mean)
    (incident__assigned__vendor): SAGEConv((-1, -1), 128, aggr=mean)
    (incident__reported__customer): SAGEConv((-1, -1), 128, aggr=mean)
    (support_org__rev_assigned__incident): SAGEConv((-1, -1), 128, aggr=mean)
    (vendor__rev_assigned__incident): SAGEConv((-1, -1), 128, aggr=mean)
    (customer__rev_reported__incident): SAGEConv((-1, -1), 128, aggr=mean)
  )
  (conv3): ModuleDict(
    (incident__assigned__support_org): SAGEConv((-1, -1), 2, aggr=mean)
    (incident__assigned__vendor): SAGEConv((-1, -1), 2, aggr=mean)
    (incident__reported__customer): SAGEConv((-1, -1), 2, aggr=mean)
    (support_org__rev_assigned__incident): SAGEConv((-1, -1), 2, aggr=mean)
    (vendor__rev_assigned__incident): SAGEConv((-1, -1), 2, aggr=mean)
    (customer__rev_reported__incident): SAGEConv((-1, -1), 2, aggr=mean)
  )
)
```

Literatura

1. Predicting help desk ticket reassignments with graph convolutional networks, Jörg Schad, Rajiv Sambasivan, Christopher Woodward, 2022

2. Hands-On Graph Neural Networks Using Python, Maxime Labonne, 2023

3. Inductive Representation Learning on Large Graphs, William L. Hamilton, Rex Ying, Jure Leskovec, 2018

4. Graph Neural Networks: A Review of Methods and Applications, Jie Zhou, Ganqu Cui, Shengding Hu, Zhengyan Zhang, Cheng Yang, Zhiyuan Liu, Lifeng Wang, Changcheng Li, Maosong Sun, 2020

5. PyG Documentation