[EMNLP2020] Event Extraction by Answering (Almost) Natural Questions

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***Input*:**

As part of the 11-billion-dollar **sale** of USA Interactive's film and television operations to the French company and its parent company in December 2001, USA Interactive received 2.5 billion dollars in preferred shares in Vivendi Universal Entertainment.

***Extracted Event*:**

Event type		Transaction-Transfer-Ownership
Trigger		"sale"
Args.	Buyer	"French company", "parent company"
	Seller	"USA Interactive"
	Artifact	"operations"
	Place	-

Motivations

1.Heavily rely on entity recognition, causing the problem of error propagation.

- identify entities and their general semantic class.
- assign argument roles to each entity.

2.Inability to exploit the similarities of related argument roles across event types.

- zero-shot scenario

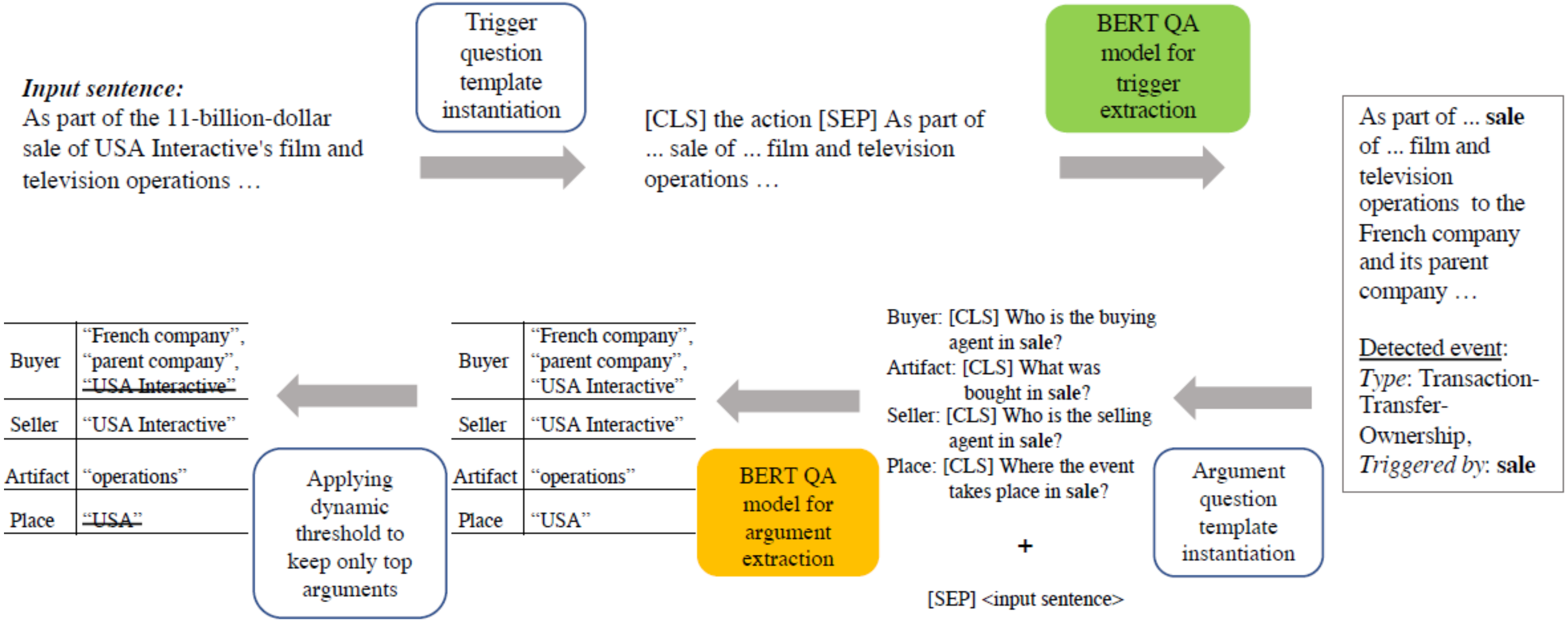
Contributions

1.Formulating event extraction tasks a question answering (QA)/ machine reading comprehension (MRC) task.

2. Treating event extraction as QA overcomes the weaknesses in existing methods.

- No entity annotation and no entity recognition; argument extraction is performed as an end-to-end task.
- Permits the transfer of argument extraction knowledge across semantically related argument roles.
- Rule-based question generation strategies.

3. Our framework extends to the zero-shot setting.



Input sentence:
As part of the 11-billion-dollar sale of USA Interactive's film and television operations …
Trigger question template instantiation
[CLS] the action [SEP] As part of … sale of … film and television operations …
BERT QA model for trigger extraction
As part of … sale of … film and television operations to the French company and its parent company …
Detected event:
Type: Transaction-Transfer-Ownership,
Triggered by: sale
Argument question template instantiation
Buyer: [CLS] Who is the buying agent in sale?
Artifact: [CLS] What was bought in sale?
Seller: [CLS] Who is the selling agent in sale?
Place: [CLS] Where the event takes place in sale?
+
[SEP] <input sentence>
BERT QA model for argument extraction
Buyer "French company", "parent company", "USA Interactive"
Seller "USA Interactive"
Artifact "operations"
Place "USA"
Applying dynamic threshold to keep only top arguments
Buyer "French company", "parent company", ~~"USA Interactive"~~
Seller "USA Interactive"
Artifact "operations"
Place ~~"USA"~~

Input sequences:

[CLS] <question> [SEP] <sentence> [SEP]

Question Generation Strategies:

- Event trigger detection: we experiment with a set of four
  - fixed templates – “what is the trigger”, “trigger”, “action”, “verb”.
  - the input sequence:

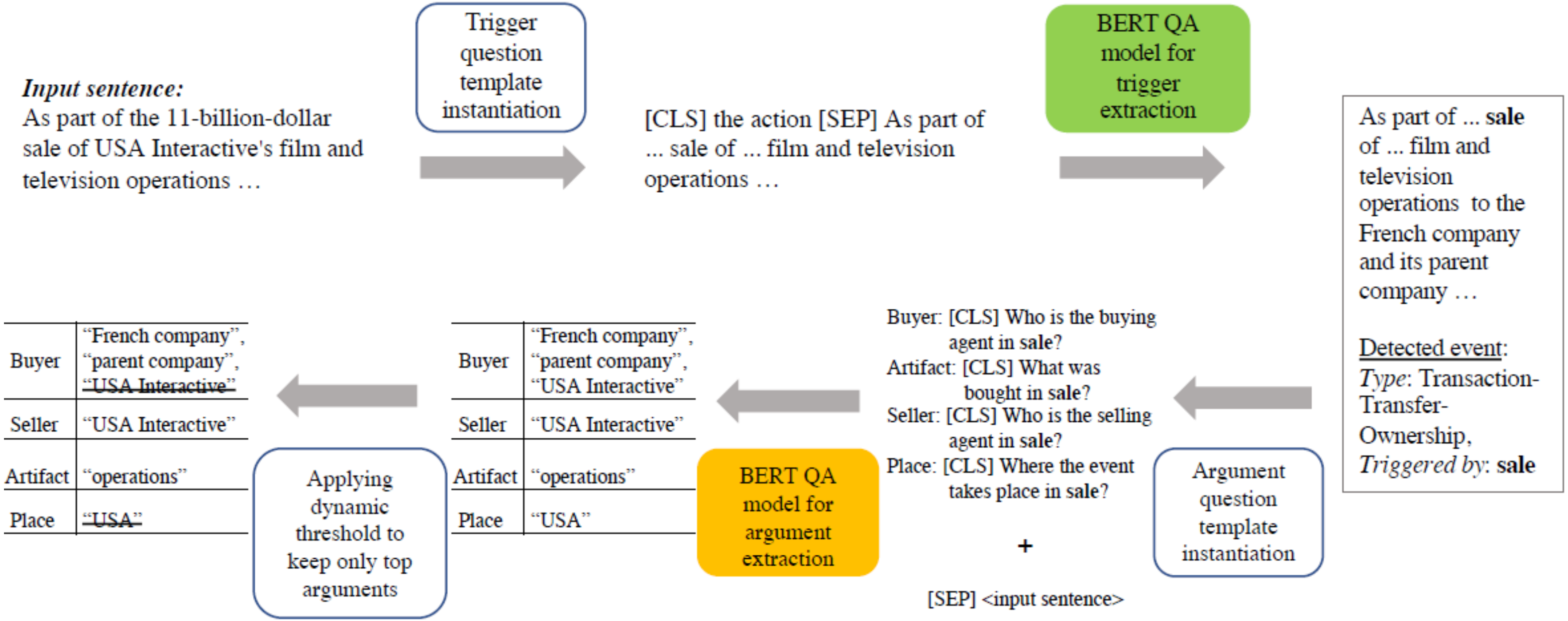
    [CLS] action [SEP] As part of the 11-billion-dollar sale ... [SEP].

Question Generation Strategies:

- Event argument extraction:
  - Template 1 (Role Name)
  - Template 2 (Type + Role)--we first determine the argument role’s general semantic type.

    eg. <WH_word> is the <role name> ?
  - Template 3 (Incorporating Annotation Guidelines)--we utilize the descriptions of each argument role provided in the ACE annotation guidelines for events.
  - + “in <trigger>”--<WH_word> is the <argument> in <trigger>?

Argument	Template 1 (Role name)	Template 2 (Type + Role question)	Template 3 (Annotation guideline question)
Artifact	artifact	What is the artifact?	What is being transported?
Agent	agent	Who is the agent?	Who is responsible for the transport event?
Vehicle	vehicle	What is the vehicle?	What is the vehicle used?
Origin	origin	What is the origination?	Where the transporting originated?
Destination	destination	What is the destination?	Where the transporting is directed?



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Question Answering Models

trigger detection

$$\mathbf{E} = [\mathbf{e}_1, \mathbf{e}_2, ..., \mathbf{e}_N]$$

$$\mathbf{e}_1, \mathbf{e}_2, ..., \mathbf{e}_N = \mathrm{BERT}_{Tr}(e_1, e_2, ..., e_N)$$

$$P_{tr} = \mathtt{softmax}(\mathbf{E}\mathbf{W}_{tr}) \in \mathbb{R}^T \times N$$

event type

argument span extraction

$$\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, ..., \mathbf{a}_M]$$

$$\mathbf{a}_1, \mathbf{a}_2, ..., \mathbf{a}_M = \mathrm{BERT}_{Arg}(a_1, a_2, ..., a_M)$$

$$P_s(i) = \mathtt{softmax}(\mathbf{a}_i\mathbf{W}_s)$$

$$P_e(i) = \mathtt{softmax}(\mathbf{a}_i\mathbf{W}_e)$$

the start and end offsets

Inference with Dynamic Threshold for Argument Spans

Algorithm 1: Harvesting Argument Spans Candidates

Input : $P_s(i)$, where $i \in \{1, ..., M\}$,
$P_e(i)$, where $i \in \{1, ..., M\}$

Output : valid candidate spans for the argument role

for $start \leftarrow 1$ **to** M **do**
    for $end \leftarrow 1$ **to** M **do**
        if *start* **or** *end not in the input sentence* **then** continue;
        if $end - start + 1 > MaxSpanLength$ **then** continue;
        if $P_s(start) < P_s([CLS])$ **or** $P_e(end) < P_e([CLS])$ **then** continue;
        `// add the valid candidate span to the set`
        $score \leftarrow P_s(start) + P_e(end)$;
        $no\_ans\_score \leftarrow P_s(1) + P_e(1) - score$;
        $candidates$.add($[start, end, no\_ans\_score]$)
    end
end

Experiments

Dataset: ACE 2005

event trigger✓: offsets ✓ + type ✓
event argument ✓: offsets ✓ +semantic role ✓

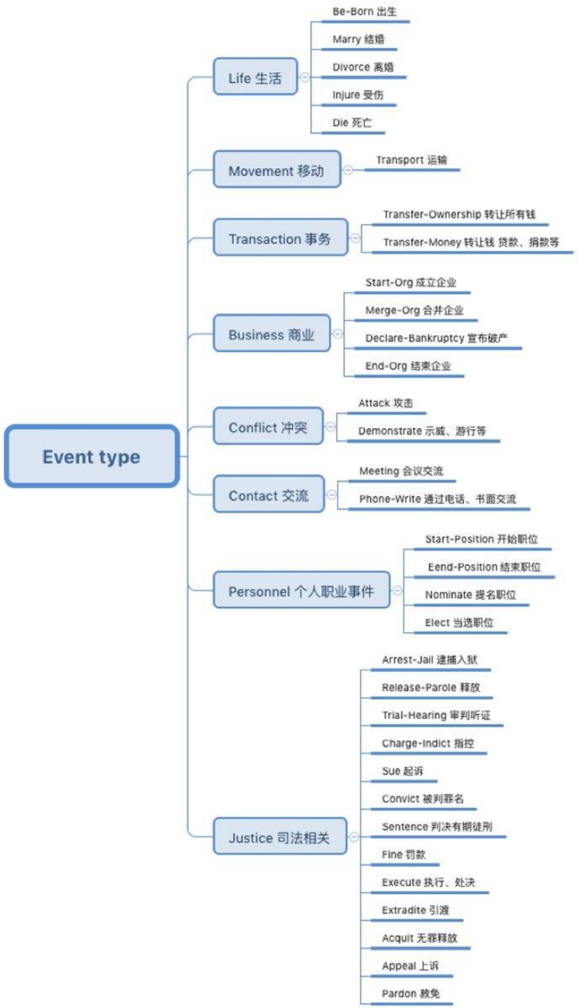

表 2-2 ACE 2005 定义的事件元素角色

Table 2-2 Event Argument Roles Defined by ACE 2005

事件类别	事件元素角色
婚嫁（Marry）	人物（Person），时间（Time），地点（Place）
攻击（Attack）	攻击者（Attacker），目标（Target），时间（Time），地点（Place）
受伤（Injure）	施事者（Agent），受害者（Victim），工具（Instrument），时间（Time），地点（Place）
出生（Be-born）	人物（Person），时间（Time），地点（Place）
任职（Start-Position）	人物（Person），时间（Time），机构（Org），地点（Place）
会面（Meet）	人物（Person），持续时间（Duration），地点（Place）
运输（Transport）	Origin（始发地），目的地（Destination），物品（Entity）
…	…

	Trigger Identification			Trigger ID + Classification		
	P	R	F1	P	R	F1
dbRNN (Sha et al., 2018)	-	-	-	74.10	69.80	71.90
Joint3EE (Nguyen and Nguyen, 2019)	70.50	74.50	72.50	68.00	71.80	69.80
GAIL-ELMo (Zhang et al., 2019b)	76.80	71.20	73.90	74.80	69.40	72.00
DYGIE++, BERT + LSTM (Wadden et al., 2019)	-	-	-	-	-	68.90
DYGIE++, BERT FineTune (Wadden et al., 2019)	-	-	-	-	-	69.70
Our BERT FineTune	69.77	76.18	72.84	67.15	73.20	70.04
BERT_QA_Trigger (best trigger question strategy)	74.29	77.42	75.82	71.12	73.70	**72.39**

Table 2: Trigger detection results.

	Argument Identification			Argument ID + Classification		
	P	R	F1	P	R	F1
dbRNN (Sha et al., 2018)	-	-	57.20	-	-	50.10
Joint3EE (Nguyen and Nguyen, 2019)	-	-	-	52.10	52.10	52.10
GAIL-ELMo (Zhang et al., 2019b)	63.30	48.70	55.10	61.60	45.70	52.40
DYGIE++, BERT + LSTM (Wadden et al., 2019)	-	-	54.10	-	-	51.40
DYGIE++, BERT + LSTM ensemble (Wadden et al., 2019)	-	-	55.40	-	-	52.50
BERT_QA_Arg (annot. guideline question template)	58.02	50.69	54.11	56.87	49.83	53.12*
w/o dynamic threshold	53.39	54.69	54.03	50.81	52.78	51.77
BERT_QA_Arg (ensemble argument question template 2&3)	58.90	52.08	55.29	56.77	50.24	**53.31**

Table 3: Argument extraction results. * indicates statistical significance ($p < 0.05$).

	Argument ID + Classification		
	P	R	F1
Random NE	26.61	24.77	25.66
GAIL (Zhang et al., 2019b)	-	-	-
Our model			
w/ Role name	73.83	53.21	61.85
w/ Type + Role Q	77.18	55.05	64.26
w/ Annot. Guideline Q	78.52	59.63	**67.79**

Table 4: Evaluation on unseen argument roles.

Future work：

It would be interesting to try incorporating broader context (e.g., paragraph/document-level context.