Terminology-based medication safety checking
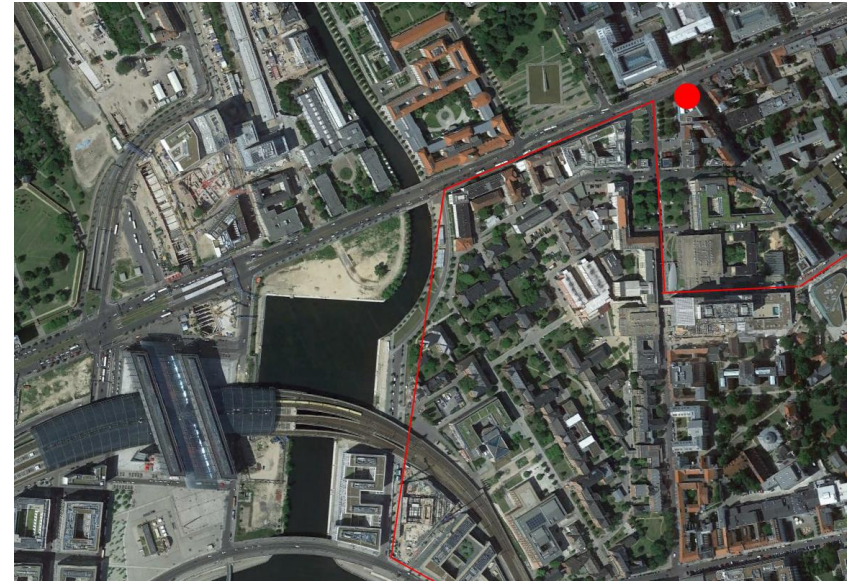
A new approach that combines ontology-based algorithms with rule-based expert knowledge

André Sander, ID Berlin

eHealth/HIMSS Summit, Vienna/Austria, 23 May 2017

ID Information und Dokumentation im Gesundheitswesen

What is ID Berlin?

- Founded in 1985

- Based in Berlin, Germany

- 75 employees
  - Physicians, pharmacists, economists, linguists, developers

- 1400 customers in 6 countries

- 6 active languages

- Maintainer of the Wingert-Nomenclature and ID MACS®

Why „medication safety„?

- Almost every person in a hospital gets a medication
- Germany had 18.073.956 inbound cases in 2015[1]

Z38	Liveborn infants according to place of birth	I63	Cerebral infarction
I50	Heart failure	I10	Essential (primary) hypertension
I48	Atrial fibrillation and atrial flutter	J18	Pneumonia, organism unspecified
S06	Intracranial injury	I21	Acute myocardial infarction
J18	Angina pectoris	K80	Cholelithiasis

- 11.3% of GDP is spent on healthcare[2]
- 15.4% of costs are for drugs (53bn)[3]

1 https://browser.inek.org/Begleitforschung/views/PrimaryDiagsProcsInpatientPdCat.xhtml?dataYear=2015
2 https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/Gesundheit/Gesundheitsausgaben/Gesundheitsausgaben.html
3 https://www-genesis.destatis.de/genesis/online/logon?language=de&sequenz=tabellen&selectionname=23611*

Current Situation

- In 10% of these cases errors occur
  → 1.76 million cases (w/o deliveries)
- 10% need a treatment of these errors (severe complications)
  → 176.000 cases
- 10% of these cases result in death
  → 17.600 cases ... roughly[1]

That are ~2% of all deaths (over all 925.200 deaths in 2015)[2]

Traffic deaths: ~3500[3] → 5 timer lower!

1 http://www.ncbi.nlm.nih.gov/pubmed/11606147
2 https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/Gesundheit/Todesursachen/Tabellen/GestorbeneAnzahl.html
3 http://de.wikipedia.org/wiki/Verkehrstod

ID Information und
Dokumentation im
Gesundheitswesen

What data is being checked?

- Demographic data
  - Age, gender, height, weight
- Medical data
  - Allergies (free text)
  - Pregnancy state, lactation, child wish, …
  - Gene / metabolism related data
- Diagnostic data
  - ICD, free text
- Prescriptions / Administrations
  - Drug, ATC or free text based
- Laboratory values
  - Used for reasoning of diagnoses

How is it checked?

- Correct indication, missing indication
- Contraindications, Interactions
- Adverse reactions
- Allergies
- Dosage (absolute and lab value related)
- Dosage schema (length, application times,…)
- Route of administration
- CYP related effects
- Cumulated effects (QT prolonging drugs, enhanced AR risk)
- Off label use
- Urgent information (Dear Doctor Letter, etc.)

Why rules engines?

- Specific knowledge for
  - Dosages
  - Indications (off label)
  - Lab value interpretation
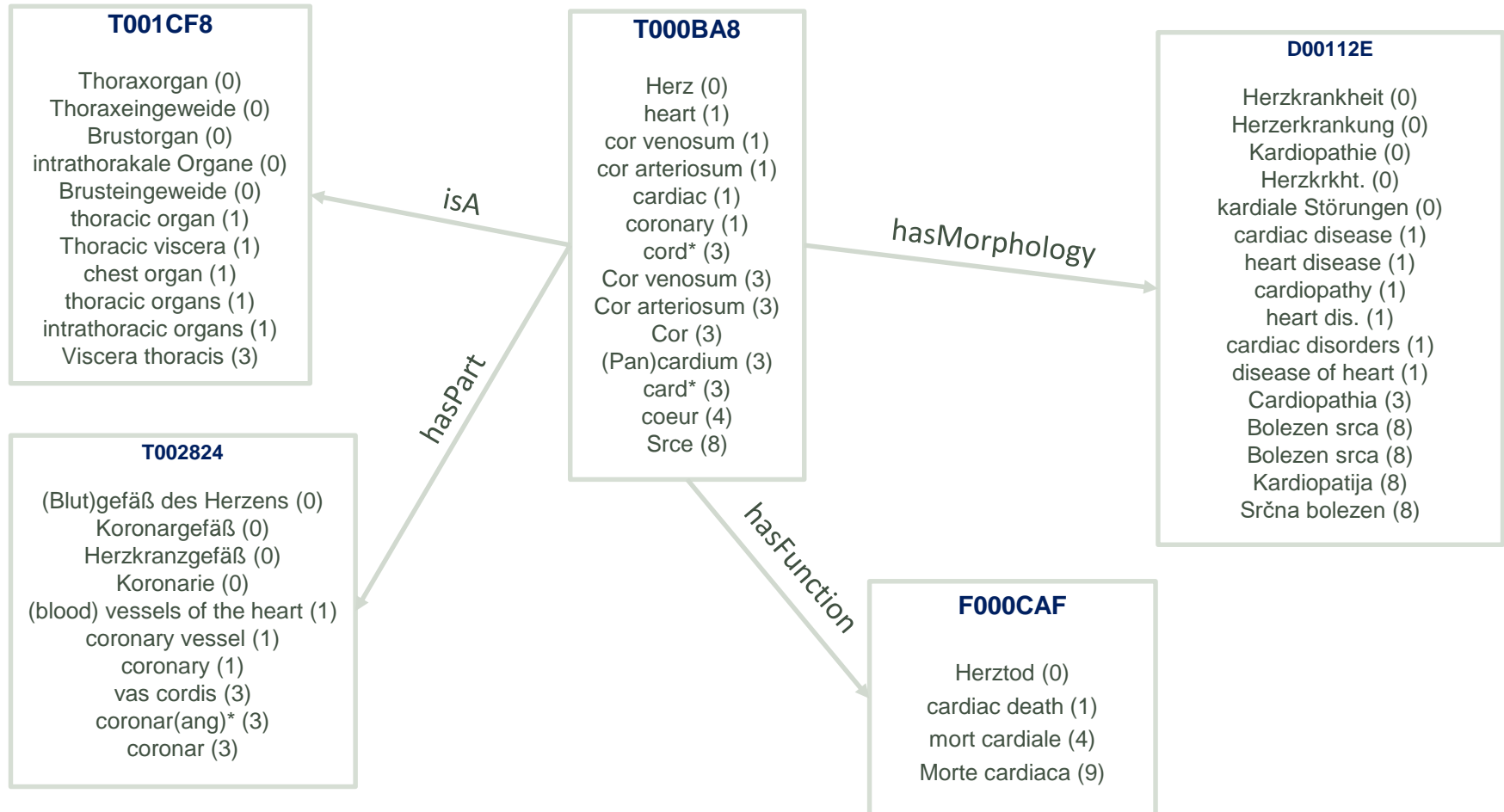 - Urgent information

Why rules engines?

- Specific knowledge for
  - Dosages
  - Indications (off label)
  - Lab value interpretation
  - Urgent information

→ Knowledge that
  - changes over time
  - is dependent from certain constraints
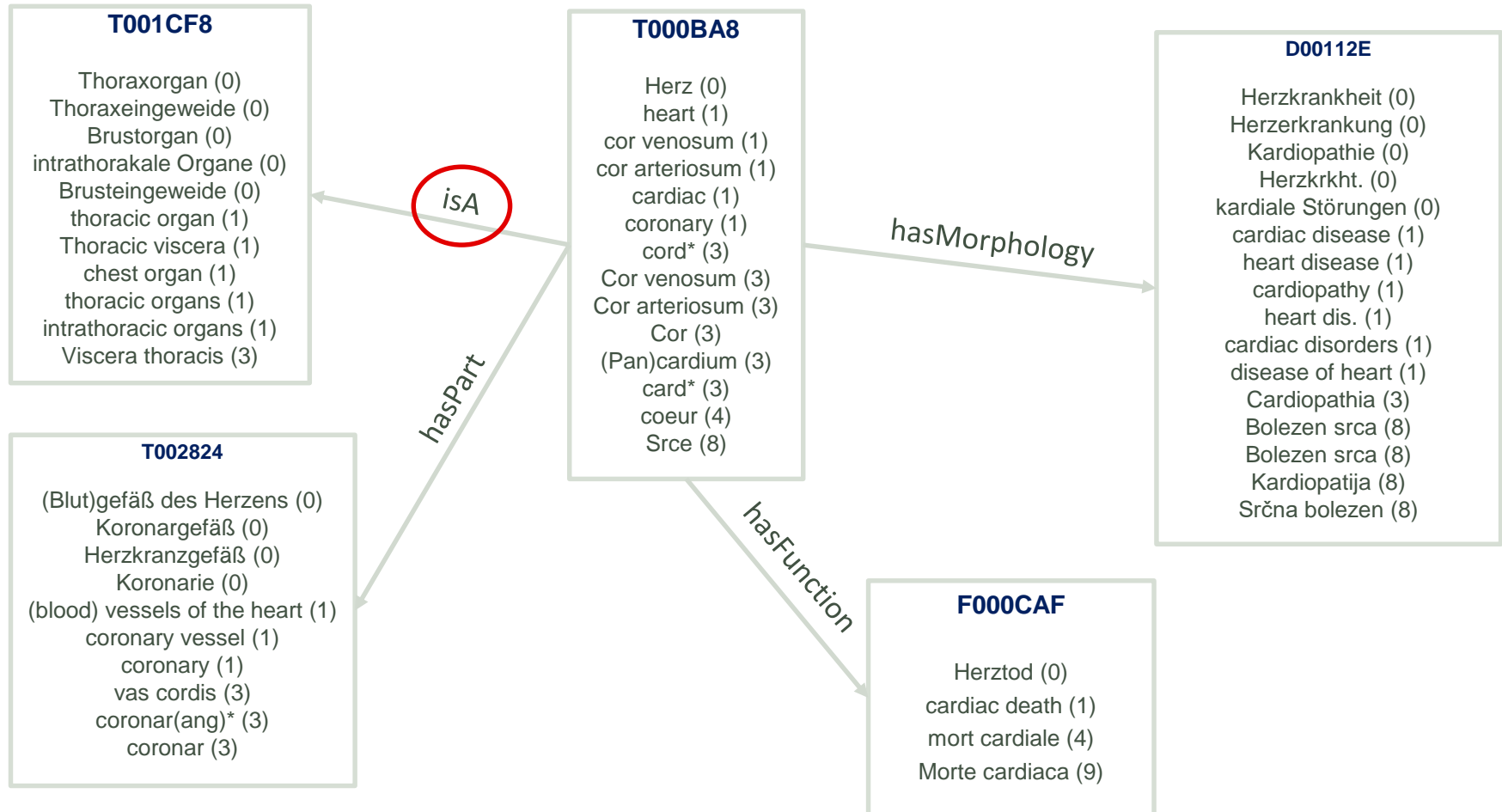 - likely being adapted by users

Why Ontologies?

Structured and language independent view of the world („domain")

Ontology sample

T001CF8

Thoraxorgan (0)
Thoraxeingeweide (0)
Brustorgan (0)
intrathorakale Organe (0)
Brusteingeweide (0)
thoracic organ (1)
Thoracic viscera (1)
chest organ (1)
thoracic organs (1)
intrathoracic organs (1)
Viscera thoracis (3)

T000BA8

Herz (0)
heart (1)
cor venosum (1)
cor arteriosum (1)
cardiac (1)
coronary (1)
cord* (3)
Cor venosum (3)
Cor arteriosum (3)
Cor (3)
(Pan)cardium (3)
card* (3)
coeur (4)
Srce (8)

D00112E

Herzkrankheit (0)
Herzerkrankung (0)
Kardiopathie (0)
Herzkrkht. (0)
kardiale Störungen (0)
cardiac disease (1)
heart disease (1)
cardiopathy (1)
heart dis. (1)
cardiac disorders (1)
disease of heart (1)
Cardiopathia (3)
Bolezen srca (8)
Bolezen srca (8)
Kardiopatija (8)
Srčna bolezen (8)

isA

hasMorphology

hasPart

hasFunction

T002824

(Blut)gefäß des Herzens (0)
Koronargefäß (0)
Herzkranzgefäß (0)
Koronarie (0)
(blood) vessels of the heart (1)
coronary vessel (1)
coronary (1)
vas cordis (3)
coronar(ang)* (3)
coronar (3)

F000CAF

Herztod (0)
cardiac death (1)
mort cardiale (4)
Morte cardiaca (9)

Ontology sample

T001CF8

Thoraxorgan (0)
Thoraxeingeweide (0)
Brustorgan (0)
intrathorakale Organe (0)
Brusteingeweide (0)
thoracic organ (1)
Thoracic viscera (1)
chest organ (1)
thoracic organs (1)
intrathoracic organs (1)
Viscera thoracis (3)

T000BA8

Herz (0)
heart (1)
cor venosum (1)
cor arteriosum (1)
cardiac (1)
coronary (1)
cord* (3)
Cor venosum (3)
Cor arteriosum (3)
Cor (3)
(Pan)cardium (3)
card* (3)
coeur (4)
Srce (8)

isA

hasMorphology

D00112E

Herzkrankheit (0)
Herzerkrankung (0)
Kardiopathie (0)
Herzkrkht. (0)
kardiale Störungen (0)
cardiac disease (1)
heart disease (1)
cardiopathy (1)
heart dis. (1)
cardiac disorders (1)
disease of heart (1)
Cardiopathia (3)
Bolezen srca (8)
Bolezen srca (8)
Kardiopatija (8)
Srčna bolezen (8)

hasPart

hasFunction

T002824

(Blut)gefäß des Herzens (0)
Koronargefäß (0)
Herzkranzgefäß (0)
Koronarie (0)
(blood) vessels of the heart (1)
coronary vessel (1)
coronary (1)
vas cordis (3)
coronar(ang)* (3)
coronar (3)

F000CAF

Herztod (0)
cardiac death (1)
mort cardiale (4)
Morte cardiaca (9)

How is it combined?

- A simple challenge:

"Create a rule, that alerts if a patient has a reduced bone density and gets a proton pump inhibitor!"

How is it combined?

Alert if a patient has a

[reduced bone density]

and gets a

[proton pump inhibitor]!

Implementation

```
maintenance:

  title:  PPI and Reduced Bone Density;;
  mlmname:  PPI_ReducedBoneDensity;;
  arden: Version 2.5;;
  version:  1.00;;
  institution:  ID;;
  author:  AS;;
  specialist:  Dr. Maximillian Koenig;;
  date:  2017-03-10;;
  validation:  testing;;

library:

  purpose:  PPI are suspected to enhance the risk of osteoporis;;
  explanation:  see action.;;
  keywords: PPI (E003230), Osteopenia (M002BF8), Osteoporosis (M0006E0);;
  citations:  ;;
  links: ;;
```

Implementation

```
maintenance:

  title:  PPI and Reduced Bone Density;;
  mlmname:  PPI_ReducedBoneDensity;;
  arden: Version 2.5;;
  version:  1.00;;
  institution:  ID;;
  author:  AS;;
  specialist:  Dr. Maximillian Koenig;;
  date:  2017-03-10;;
  validation:  testing;;

library:

  purpose:  PPI are suspected to enhance the risk of osteoporis;;
  explanation:  see action.;;
  keywords: PPI (E003230), Osteopenia (M002BF8), Osteoporosis (M0006E0);;
  citations:  ;;
  links: ;;
```

Implementation

```
knowledge:

  type:  data-driven;;

  data:
    trigger:= event {E003230}; /* PPI */

    wncMatches:= interface {wncMatches};
    pznMatches:= interface {pznMatches};
    tradeNameMatches:= interface {tradeNameMatches};
    hasIndex:= interface {hasIndex};

    urlDoc := "";

    ;;

  evoke:   any of (trigger);;

  logic:

    has_BoneDensityReduction:= call hasIndex with "M0023ED";

    conclude has_BoneDensityReduction;

   ;;

  action:

    has_Osteoporosis:= call hasIndex with "M0006E0";
    if (has_Osteoporosis) then
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_OSTEOPOROSIS}|||0|" || urlDoc ||
            "|E003230";
    else
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_BONE_DENSITY_REDUCTION}|||0|" || urlDoc ||
            "|E003230";
    endif;
  ;;
```

Implementation

```
knowledge:

  type:  data-driven;;

  data:
    trigger:= event {E003230};  /* PPI */

    wncMatches:= interface {wncMatches};
    pznMatches:= interface {pznMatches};
    tradeNameMatches:= interface {tradeNameMatche
    hasIndex:= interface {hasIndex};

    urlDoc := "";

    ;;

  evoke:   any of (trigger);;

  logic:

    has_BoneDensityReduction:= call hasIndex with

    conclude has_BoneDensityReduction;

   ;;

  action:

    has_Osteoporosis:= call hasIndex with "M0006E0";
    if (has_Osteoporosis) then
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_OSTEOPOROSIS}|||0|" || urlDoc ||
            "|E003230";
    else
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_BONE_DENSITY_REDUCTION}|||0|" || urlDoc ||
            "|E003230";
    endif;
  ;;
```
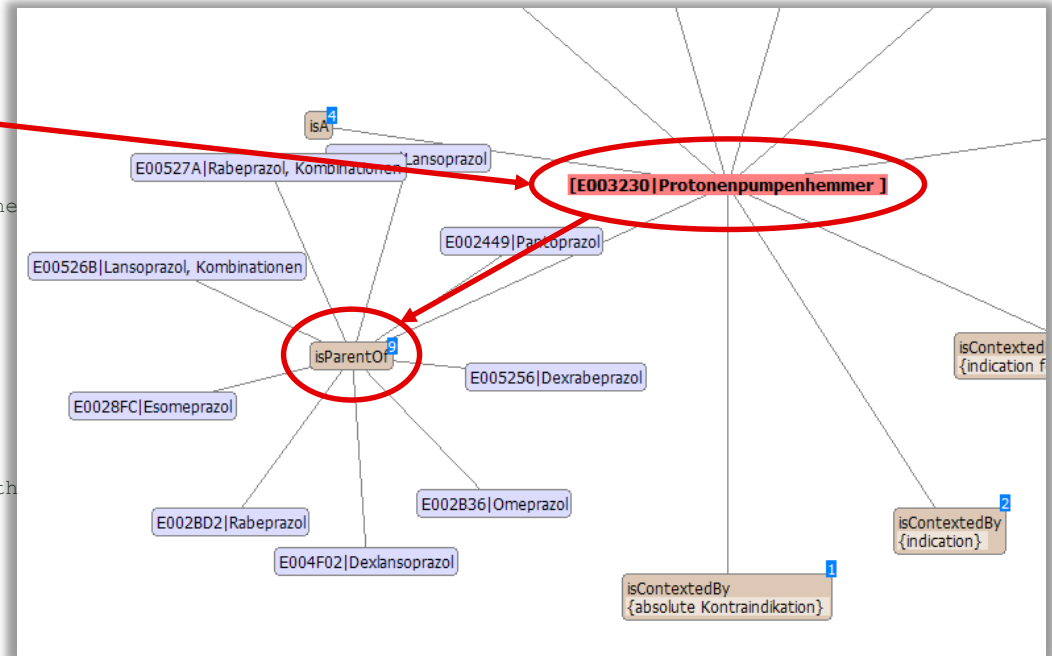
ID Information und
Dokumentation im
Gesundheitswesen

Implementation

```
knowledge:

  type:  data-driven;;

  data:
    trigger:= event {E003230}; /* PPI */

    wncMatches:= interface {wncMatches};
    pznMatches:= interface {pznMatches};
    tradeNameMatches:= interface {tradeNameMatches};
    hasIndex:= interface {hasIndex};

    urlDoc := "";

    ;;

  evoke:   any of (trigger);;

  logic:

    has_BoneDensityReduction:= call hasIndex with "M0023ED"

    conclude has_BoneDensityReduction;

   ;;

  action:

    has_Osteoporosis:= call hasIndex with "M0006E0";
    if (has_Osteoporosis) then
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_OSTEOPOROSIS}|||0|" || urlDoc ||
            "|E003230";
    else
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_BONE_DENSITY_REDUCTION}|||0|" || urlDoc ||
            "|E003230";
    endif;
  ;;
```
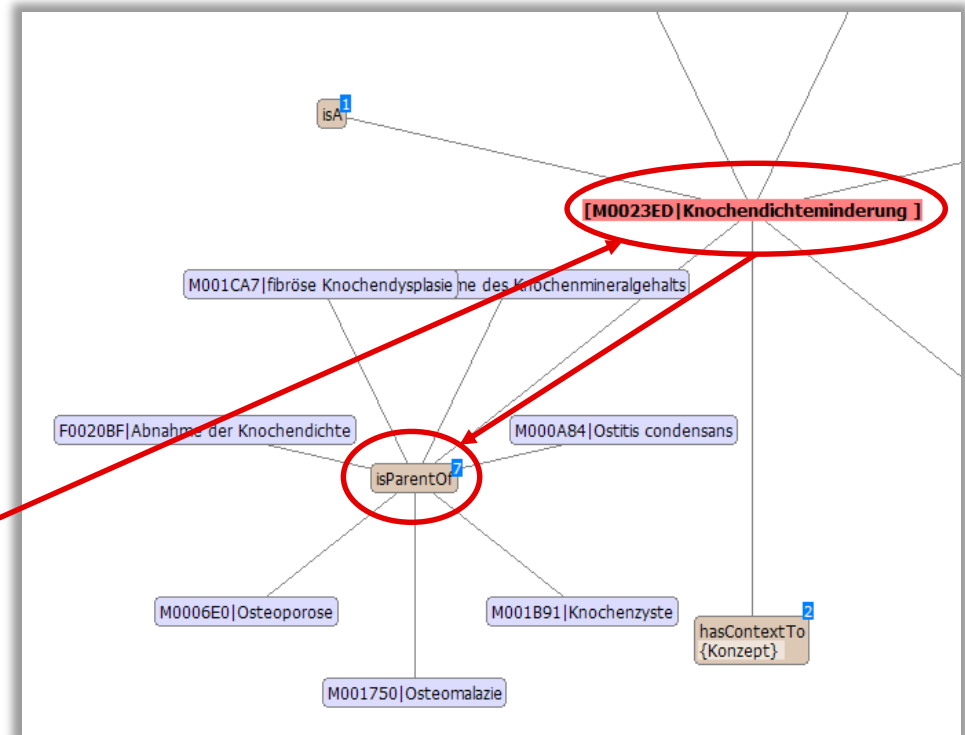
Implementation

```
knowledge:

  type:  data-driven;;

  data:
     trigger:= event {E003230}; /* PPI */

     wncMatches:= interface {wncMatches};
     pznMatches:= interface {pznMatches};
     tradeNameMatches:= interface {tradeNameMatches};
     hasIndex:= interface {hasIndex};

     urlDoc := "";

     ;;

  evoke:   any of (trigger);;

  logic:

     has_BoneDensityReduction:= call hasIndex with "M0023ED";

     conclude has_BoneDensityReduction;

   ;;

  action:

     has_Osteoporosis:= call hasIndex with "M0006E0"
     if (has_Osteoporosis) then
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_OSTEOPOROSIS}|||0|" || urlDoc ||
             "|E003230";
     else
        return "-1|-1|WN|393219|V0010AE|${rs_PCHK_TYPE_393219L}|${E003230}|${rs_PH_WN_PPI_BONE_DENSITY_REDUCTION}|||0|" || urlDoc ||
             "|E003230";
     endif;
  ;;
```
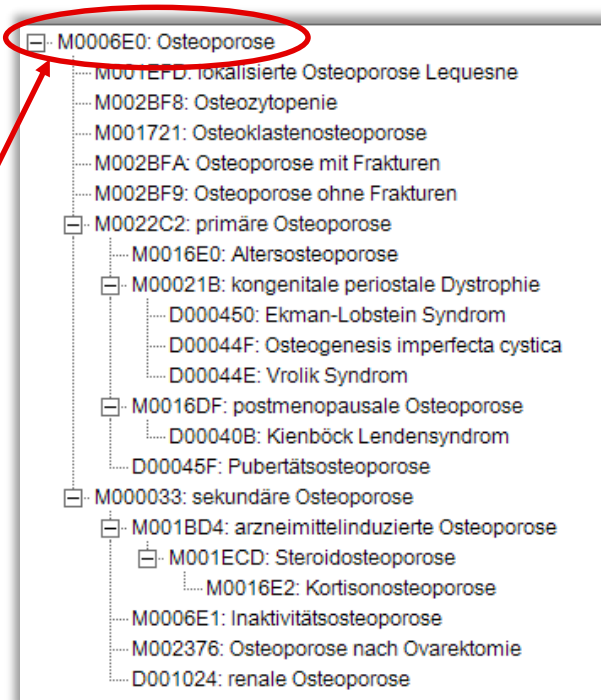

Tree view:
- M0006E0: Osteoporose
  - M001EFD: lokalisierte Osteoporose Lequesne
  - M002BF8: Osteozytopenie
  - M001721: Osteoklastenosteoporose
  - M002BFA: Osteoporose mit Frakturen
  - M002BF9: Osteoporose ohne Frakturen
  - M0022C2: primäre Osteoporose
    - M0016E0: Altersosteoporose
    - M00021B: kongenitale periostale Dystrophie
      - D000450: Ekman-Lobstein Syndrom
      - D00044F: Osteogenesis imperfecta cystica
      - D00044E: Vrolik Syndrom
    - M0016DF: postmenopausale Osteoporose
      - D00040B: Kienböck Lendensyndrom
    - D00045F: Pubertätsosteoporose
  - M000033: sekundäre Osteoporose
    - M001BD4: arzneimittelinduzierte Osteoporose
      - M001ECD: Steroidosteoporose
        - M0016E2: Kortisonosteoporose
    - M0006E1: Inaktivitätsosteoporose
    - M002376: Osteoporose nach Ovarektomie
    - D001024: renale Osteoporose

ID Information und Dokumentation im Gesundheitswesen

Conclusion

- Efficient and compact way of creating rules

- Integrating free text into (otherwise) structured rules

- Separating immanent from rule based knowledge

- Todo: Using a more standardized syntax

Contact

ID Information und Dokumentation
im Gesundheitswesen GmbH & Co. KGaA
Platz vor dem Neuen Tor 2
D-10115 Berlin
Tel: +49-(0)30-2 46 26-0
Fax: +49-(0)30-2 46 26-111
E-Mail: info@id-berlin.de