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# Arden Syntax

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## What is Arden Syntax ?

- ... a language used for representing and sharing medical knowledge.
  - ... used for sharing computerized health knowledge bases across personnel, information systems, and institutions.
  - ... organized in modules. Each module referred to as a Medical Logic Module (MLM) contains sufficient knowledge to make a single decision.
  - ... an executable format that can be used by clinical decision support systems.
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## Arden Syntax – Fundamentals I

- In Arden Syntax, medical knowledge is arranged within Medical Logic Modules (MLMs)
- Each MLM represents sufficient knowledge to make a single clinical decision
- One or more MLMs are stored within a file that has the extension “.mlm”
- Each MLM is well organized and structured into categories and slots with specific content
- An MLM is composed of slots, grouped into the following **four** required **categories: maintenance, library, knowledge, and resources**
- Categories must appear in the correct order
- Within each category is a set of **slots** that must appear in the correct order, too

```
maintenance:
  title:      [TITLE_(needed)];;
  mlmname:   [MLM-NAME_(needed)];;
  arden:     Version 2.5;;
  version:   [MLM-VERSION_(needed)];;
  institution: [INSTITUTION_(needed)];;
  author:    ;;
  specialist: ;;
  date:      [DATE];;
  validation: testing;;
library:
  purpose:    ;;
  explanation: ;;
  keywords:   ;;
  citations:  ;;
  links:     ;;
knowledge:
  type:      data_driven;;
  data:      ;;
  priority:  ;;
  evoke:     ;;
  logic:
    conclude true;
  ;;
  action:
  ;;
  urgency:  ;;
end:
```

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## Arden Syntax – Fundamentals II

- MLMs are working in close contact with their host system. Ways of interaction are:
    - **Input:** By calling an MLM, an input parameter can be committed
    - **Curly Brace Expressions:** So called “curly brace expressions” implement a special kind of dynamic interaction between MLMs and host systems
    - **Write Statements:** Texts can be written to destinations that are maintained by the host system
    - **Output:** Analogous to the input parameter, data can be committed from the MLM to the host system after the execution of the MLM has finished
  - In order to start the execution of an MLM, an engine is needed that handles communication with the host system and can tell which of the MLMs is available
  - Ways to start running an MLM:
    - **MLM call:** An MLM is directly called
    - **Event call:** Any MLM that listens to a specific event is executed
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## Arden Syntax – Fundamentals III

- Data types
  - Statements, expressions (assignments, loops, variables, constants, objects)
  - Operators
    - List operators
    - Logical operators
    - Comparison operators
    - String operators
    - Arithmetic operators
    - Temporal operators
    - Aggregation operators
    - Time and object operators
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## Primary Time

- In addition to its value part, each data value has a **primary time** part and an degree of applicability
  - Primary time represents the value part's time of creation or measurement or examination or ...
  - By default, primary time is `null`
  - Can be accessed using the `time` operator  

```
2016-03-15T00:00:00 := time of laboratory_result
```
  - Database query results should contain both, the value and the primary time
    - Might be the time when a blood test was drawn from the patient
    - Might be the time when a medication order was placed
    - Which time of a database entry is taken as primary time is left to Arden Syntax implementer
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## History

- A first draft of the standard was prepared at a meeting at the Arden Homestead, New York, in 1989. Arden Syntax was subsequently adopted as a standard by the American Society for Testing and Materials (ASTM) as document E 1460, under subcommittee E 31.15 Health Knowledge Representation.
- 1992: Arden Syntax version 1.0
- 1998: sponsorship moved to HL7 International (Arden Syntax Work Group)
- 1999: Arden Syntax version 2.0 approved by HL7 and the American National Standards Institute (ANSI)
- 2014: Arden Syntax version 2.10



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## History

Version	Year	Important changes
2.1	2002	new string operators; reserved word "currenttime" returns the system time
2.5	2005	object capabilities: create and edit objects; XML representation of MLMs (except logic, action and data slot)
2.6	2007	UNICODE encoding; additional resources category to define text resources for specific languages; time-of-day and day-of-week data types; "localized" operator to access texts in specific languages
2.7	2008	enhanced assignment statement; extended "new" operator to allow easy and flexible object instantiation
2.8	2012	additional operators for list manipulation; operators to manipulate parts of given date and time values; switch statements; keyword "breakloop" for aborting a loop; number of editorial corrections
2.9	2013	<b>fuzzification</b> : fuzzy data types and fuzzy sets; adjustment of all available operators to be able to handle fuzzy data types
2.10	2014	<b>XML representation</b> of whole MLMs (including logic, action and data slot)

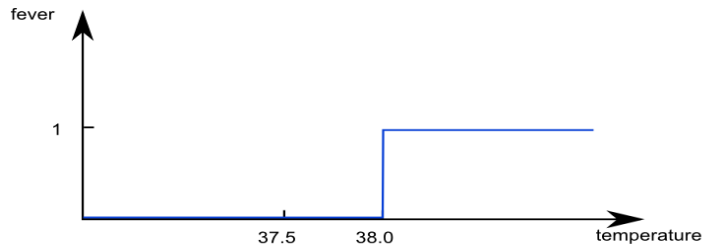
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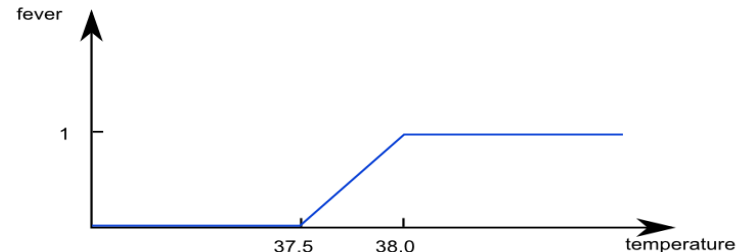
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## Fuzzy Sets – Background I

- **Crisp** boundary
  - Defines a **sharp** threshold
  - Checking if a given value is greater or less than the defined crisp threshold results in either true or false
  - Borderline cases are not detected



- **Fuzzified** boundary
  - Defines a **gradual** transition
  - Checking if a given value is greater or less than the defined fuzzified boundary results in a truth value between 0 and 1
  - Borderline cases are detected
  - Weighted results for borderline cases, all other are as usual



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## Fuzzy Sets – Example I

- **Classical** Arden Syntax

```
fever_limit := 38;  
temperature := 37.9;
```

```
message := "patient has no fever";  
IF temperature > fever_limit THEN  
    message := "patient has fever";  
END IF
```

- Result message: "patient has no fever"
- Borderline case is not detected

- **Fuzzy** Arden Syntax

```
fever_limit := FUZZY SET (37.5,0), (38,1);  
temperature := 37.9;
```

```
message := "patient has no fever";  
IF temperature > fever_limit THEN  
    message := "patient has fever";  
END IF
```

- Result message: "patient has fever" (with applicability 0.8)
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## How to execute MLMs

- **MLM calls:** When the MLM call statement is executed, the current MLM is interrupted, and the named MLM is called; parameters are passed to the named MLM

```
/* Define find_allergies MLM */  
find_allergies := MLM 'find_allergies';  
(allergens, reactions) := call find_allergies;
```

- **Event calls:** When the event call statement is executed, the current MLM is interrupted, and all the MLMs whose evoke slots refer to the named event are executed; parameters are passed to the named MLMs

```
allergy_found := EVENT {allergy found};  
reactions := call allergy_found;
```

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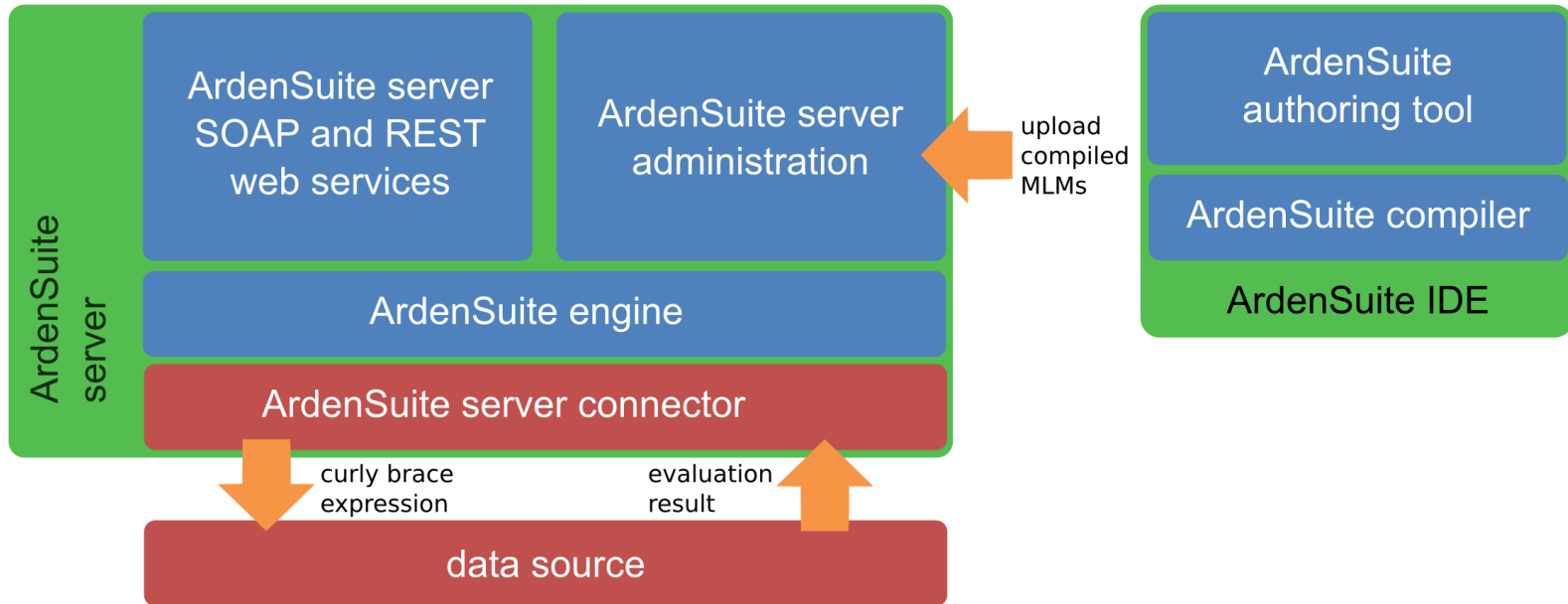
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## How to get data into MLMs

- MLM and event calls
  - Provide data to an other MLM
  - Read data provided to the actual MLM
  - Return data to calling MLM or instance
- Curly brace expressions
  - Read data from external data sources
  - Write data to external data sources
  - Call external applications or interfaces

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## How to get data into MLMs – Curly Brace Expressions



# How to execute MLMs – Web Service Usage

The screenshot shows the Hepaxpert web application in a browser. The page is titled "Hepaxpert" and is divided into three main sections for Hepatitis A, B, and C serology. Each section contains a list of test results with colored buttons indicating the status (e.g., positive, negative, not tested). Below the test results, there is a paragraph of text explaining the clinical significance of the findings. At the bottom of the page, there are navigation buttons: "Zurück", "Neue Eingabe", and "Information".

**Hepatitis-A-Serologie**

Anti-HAV (red) | IgM-anti-HAV (green) | HAV-RNA (grey)

Positive Gesamtkörper (Anti-HAV) bei negativen IgM-anti-HAV-Antikörpern beweisen Immunität gegen das Hepatitis-A-Virus und schließen eine rezente Hepatitis A aus. Diese Immunität kann entweder durch eine frühere Infektion natürlich erworben oder aber durch aktive Impfung oder passive Immunisierung induziert sein.

**Hepatitis-B-Serologie**

HBsAg (red) | Anti-HBs (red) | Anti-HBc (green) | IgM-anti-HBc (green) | HBeAg (red) | Anti-HBe (orange) | Anti-HBs Titer (grey)

Das gleichzeitige Auftreten von HBe-Antigen und Anti-HBs-Antikörpern ist im natürlichen Verlauf einer Hepatitis-B-Virusinfektion ein seltenes Ereignis. Diese Befundkonstellation ist entweder auf (a) zirkulierende HBsAg-Anti-HBs-Immunkomplexe, (b) auf eine Konvaleszenz einer Hepatitis-B-Virusinfektion mit einer Hepatitis-B-Impfung oder Injektion von HB-Hyperimmunglobulin oder (c) eine Reinfektion mit einem Hepatitis-B-Virus mit unterschiedlichem HBsAg-Subtypus zurückzuführen. Blut und Sekrete (Speichel, Sperma, Muttermilch) solcher Patienten sind als infektiös anzusehen. Zur Kontrolle des nicht eindeutig negativen oder positiven Befundes wird neuerliche Materialeinsendung bzw. Rücksprache mit dem Laborleiter empfohlen.

**Hepatitis-C-Serologie**

Anti-HCV (green) | HCV-RNA (grey)

Der erhobene Befund gibt keinen Hinweis auf eine bestehende oder frühere Hepatitis-C-Virusinfektion, schließt aber diese nicht mit Sicherheit aus. In seltenen Fällen kann trotz negativer HCV-Antikörper HCV-RNA im Serum nachgewiesen werden. Trotzdem wird in der Praxis Anti-HCV negatives Blut (auch ohne Information über HCV-RNA) als nicht infektiös hinsichtlich Hepatitis C angesehen.

The screenshot shows the Hepaxpert mobile application interface. The app is titled "Hepaxpert" and is divided into three main sections for Hepatitis A, B, and C serology. Each section contains a list of test results with colored buttons indicating the status (e.g., positive, negative, not tested). Below the test results, there is a paragraph of text explaining the clinical significance of the findings. At the bottom of the app, there are navigation buttons: "Interpretation", "About", "Back", "New Input", and "About".

**Hepaxpert**

**Input of test results**

**Hepatitis A Serology**

anti-HAV (red) positive | IgM anti-HAV (grey) not tested | HAV-RNA (grey) not tested

**Hepatitis B Serology**

HBsAg (green) negative | anti-HBs (grey) not tested | anti-HBc (grey) not tested | IgM anti-HBc (green) negative | HBeAg (grey) not tested | anti-HBe (grey) not tested | anti-HBs titre (120) UI/l

**Hepatitis C Serology**

anti-HCV (green) negative | HCV-RNA (grey)

This constellation of findings (positive anti-HBs antibodies, with negative IgM anti-HBc antibodies) indicates the presence of immunity to the hepatitis virus B. This immunity may either have been acquired naturally upon restitution following a hepatitis B virus infection or it may have been induced by active or passive immunization.

**Vaccination Recommendation:** If an indication for a hepatitis B vaccination exists, the primary course of immunization has been completed, the last partial vaccination was given at least 1 month previously, and the vaccinated person's immunity is unimpaired, then a hepatitis B vaccination (or a follow-up anti-HBs titre check) within 1 year, based on the titre examination date, is to be recommended at the measured anti-HBs titre value of 120.

# How to execute MLMs – Web Service Usage

⚙️ Fall/Außerhalb Patient: Patth., ██████████ Dok.OE: Station 17H  
🖨️ Druck/Adresse/atem Fall: Gesanter Patient  
📄 Dokumentstatus  
👤 Externe Ärzte Bewegung: Gesanter Patient  
📁 Kontaktdaten

Schema: SOP Nr. 2 - Dacarbazine 800mg  - in klinischer Validierung

**Pra-Chemotherapie Checkliste**

Text	Bemerkung	14.04.2011	04.04.2011	31.03.2011
Verabreichungen			3	
Labor		14.04.2011	04.04.2011	31.03.2011
Blutbild				
• Erythrozyten	> 4.0 Td	4.1	4	4
• Hämoglobin	> 12.0 g/dl	12.3	12	12
• Leukozyten	> 3.0 Gd	3	3	3
• Thrombozyten	> 100 Gd	105	100	100
Metaboliten				
• Creatinin	< 1.2 mg/dl	1.3	1.2	1.2
Entzündungsparameter				
• CRP	< 1 mg/dl	1	1	1
Allgemeinzustand				
• ECOG State		1	1	1
Wissensbasiertes System		<input type="button" value="Prüfen"/>	<input type="button" value="Prüfen"/>	<input type="button" value="Prüfen"/>
Empfehlung			akzeptiert	akzeptiert
Status			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Erklärung			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Sonstiges				
Bemerkung				
Freigabe				
Storno				

Medexter Demo KIS

🏠 Dashboard  
👤 Patients  
🔬 Laboratory  
🚑 Ambulance  
📄 Forms  
💊 Medication  
📊 Reporting  
⚙️ Preferences

**Bauer, Stefanie**  
 Sex: Female NINO: 123410068  
 Age: 44 Case Number: 458897  
 Date of Birth: 18/07/1970 Hospital Admittance: 14/04/2015

17/04/2015 13:46

	17/04/2015 13:02	16/04/2015 12:52	15/04/2015 11:29	14/04/2015 13:37
<b>HEMATOLOGICAL PROFILE</b>				
Leucocytes	19.4	20.1	17.5	17.1
Hemoglobin	-	-	-	-
...				
<b>BIOCHEMICAL PROFILE</b>				
<b>Electrolytes</b>				
Potassium	-	-	-	-
Kaese, Franz				
<b>Inflammation markers</b>				
C reactive protein	169	105	98	80
Letmaye, Sonja				
<b>Kidney function</b>				
Blood urea nitrogen	-	-	-	-
Mate, Franz				
Serum creatinine	-	-	-	-
Mate, Sabine				
Urea	-	-	-	-
Neuwirt, Markus				
<b>Enzymes</b>				
Schneider, Stefan				
Tropoin	-	-	-	-
Schl, Anta				
...				

**Clinical Alerts**

GENERATED	MESSAGES
17/04/2015 13:02	<b>Persistent leukocytosis</b>
17/04/2015 13:02	<b>Further increase of CRP</b> Further increase of CRP (169 mg/L, 17/04/2015 13:02) compared to previous finding (105 mg/L, 16/04/2015 12:52)
16/04/2015 12:52	<b>CRP 105.0 mg/L</b> 16/04/2015 12:52 CRP 105.0 mg/L 16/04/2015 11:29 CRP 98.0 mg/L 14/04/2015 13:37 CRP 80.0 mg/L
16/04/2015 12:52	<b>Further increase of leukocytes</b>
14/04/2015 13:37	<b>Leukocyte value indicates leukocytosis</b>
14/04/2015 13:37	<b>Moderately increased CRP</b>