Shallow Language Generation
TG/2, XtraGen, eGram

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Application Systems for NLG Must be Developed Quickly and in a User-Oriented Way

- **Requirements placed by the application**
  - on the user: recognize and articulate needs
  - on the developer: make herself acquainted with the domain
  - on both: create and adapt a corpus of sample target texts
- **Requirements wrt the software**
  - Adaptability to new tasks and domains
  - Scalability (low costs of the next rule)
  - Modularisation (interpreter, daten, knowledge, interfaces)

High efficiency of development is difficult to achieve with traditional approaches to language generation

Non-Trivial Generation Systems are Expensive to Adapt to New Domains and Tasks

- **Examples**
  - KPML (Bateman et al.), systemic grammars, development environment
  - FUF/Surge (Elhadad/Robin), functional unification grammar, interpreter
- **Features**
  - large multi-lingual systems
  - detailed, monolingual semantic representations as input
  - broad coverage of linguistic phenomena (goal: the more, the better)
- **Effort for adaptation**
  - Rich interface to the input language of the system (logical form, SPL)
  - Generation of sentences reflecting the distinctions covered

The excellent scope of services of generic resources can often not be utilised in practice

Source: Stephan Busemann

In Addition to In-Depth NLG, Shallow Approaches are being Pursued

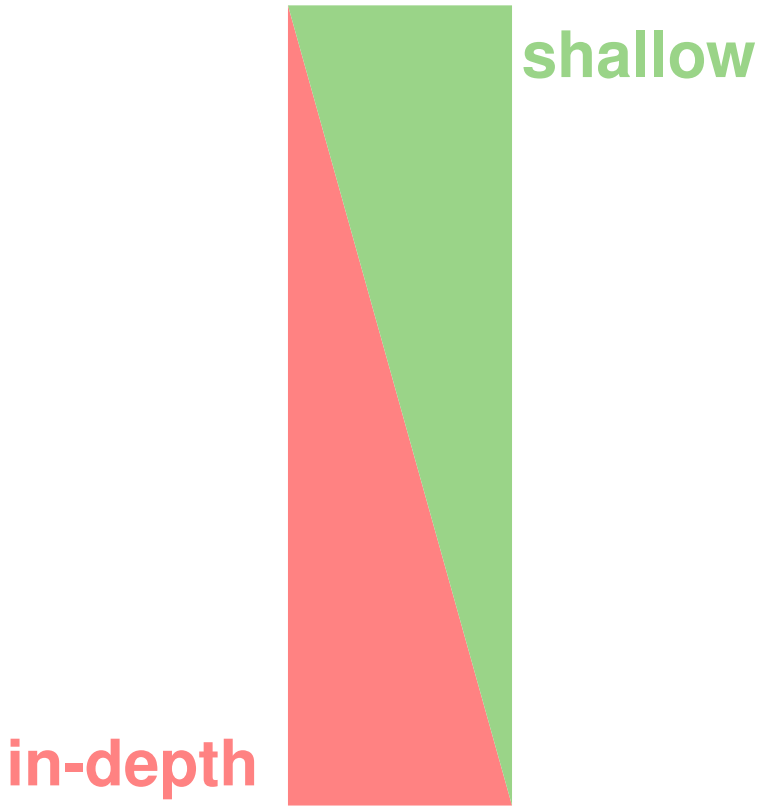
- **In-depth generation**
  - knowledge-based (models of the domain, of the author and the addressees, of the language(s) involved)
  - theoretically motivated, aiming at generic, re-usable technology
  - unresolved issue of general system architecture
- **Shallow generation**
  - opportunistic modelling of relevant aspects of the application
  - diverse depth of modelling, as required by the application
  - some methods viewed as „short cuts“ for unsolved questions of in-depth generation

Shallow generation can be defined in analogy to shallow analysis

Source: Stephan Busemann

There is a Smooth Transition Between Shallow and Deep Methods

- Prefabricated texts
- „Fill in the slots“
- with flexible templates
- with aggregation
- with sentence planning
- with document planning



Source: Stephan Busemann

Shallow Architectures Have a Simple Task Structure

"In-Depth" model with interaction (cf. Reiter/Dale 2000)

Content Determination
Discourse Planning

Sentence Aggregation
Lexicalisation
Generation of Referring Expressions

Surface Realisation

„Shallow" Model (Busemann/Horacek 1998)

Content Determination

Text Organisation (Aggregation)

Mapping Onto Linguistic Structures

Source: Stephan Busemann

Overview

- Motivation
- The TG/2 NLG framework
- Some major applications
- Modifications and extensions
- Assessment and conclusions

Input for Air Quality Report Generation

```
[(COOP threshold-passing)
 (TIME [(PRED season)
        (NAME [(SEASON summer)
               (YEAR 1999)])])
 (POLLUTANT o3)
 (SITE "Völklingen-City")
 (DURATION [(MINUTE 60)])
 (SOURCE [(LAW-NAME bimsch)
          (THRESHOLD-TYPE info-value)])
 (EXCEEDS [(STATUS yes)
           (TIMES 1)])]
```

In summer 1999 at the measuring station of Völklingen-City, the information value for ozone – 180 µg/m³ according to the German decree Bundesimmissions-schutzverordnung – was exceeded once during a period of 60 minutes.

Source: Stephan Busemann

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Im Sommer 1999 wurde der Informationswert für Ozon an der Messstation Völklingen-City während einer 60-minütigen Einwirkungsdauer (180 µg/m³ nach Bundesimmissionsschutzverordnung) einmal überschritten.

Source: Stephan Busemann

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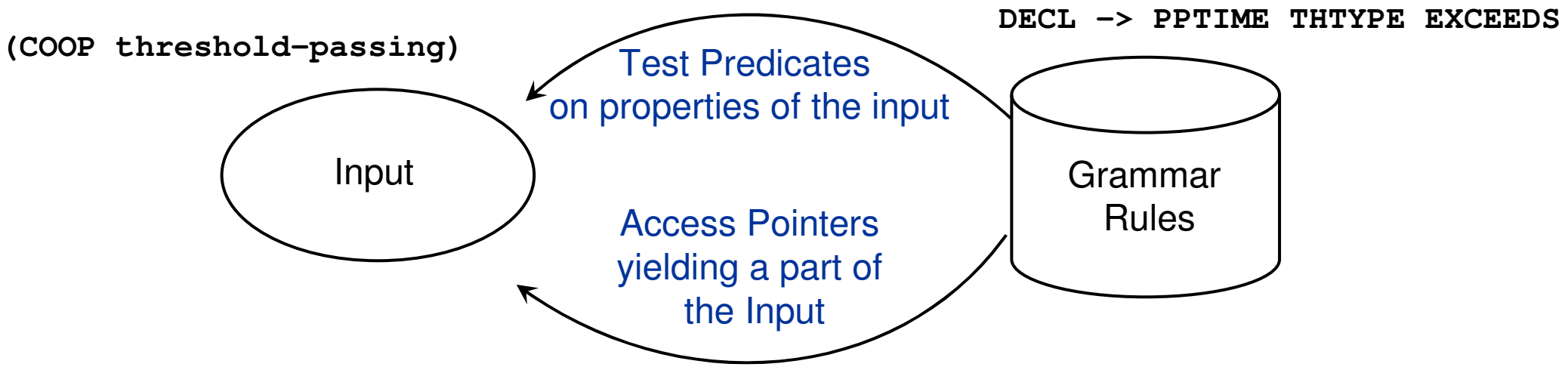
Source: Stephan Busemann

TG/2 Offers a Flexible Framework for NLG

- **TG/2 is a transparent production system**
- **TG/2 interprets a separately defined set of condition-action rules**
- **TG/2 maps pieces of input onto surface strings**

TG/2 keeps grammars largely independent from input representations



TG/2 Grammars Integrate Canned Texts, Templates and Context-free Rules

```
My category is DECL.
IF the slot COOP is 'threshold-passing
   AND the slot LAW-NAME is specified
THEN apply PPtime from slot TIME
     apply THTYPE from CURRENT-INPUT
     utter "("
     apply LAW from slot LAW-NAME
     utter ") "
     apply EXCEEDS from slot EXCEEDS
     utter "."
WHERE THTYPE AND EXCEEDS agree in GENDER
```

(Busemann 1996)

En été 1999
la valeur limite autorisée
(
selon le decret ...
)
a été dépassée une fois
.

```
My category is THTYPE.
IF there is no slot THRESHOLD-TYPE specified
THEN utter "la valeur limite autoris&e2e "
WHERE THTYPE has value 'fem for GENDER
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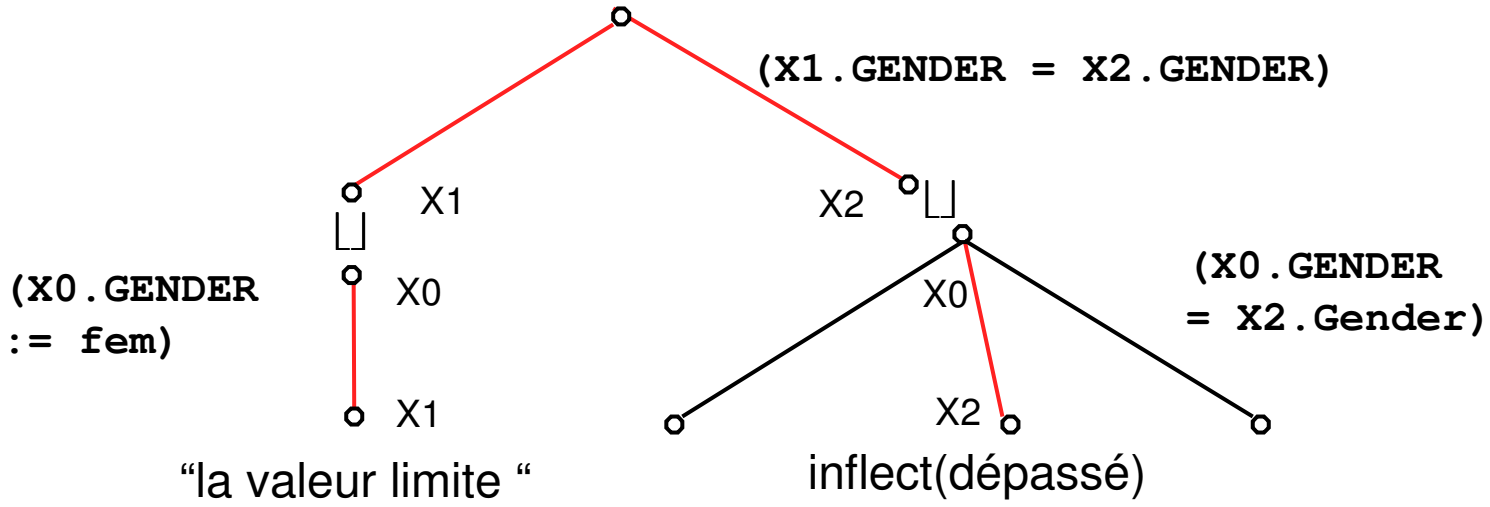
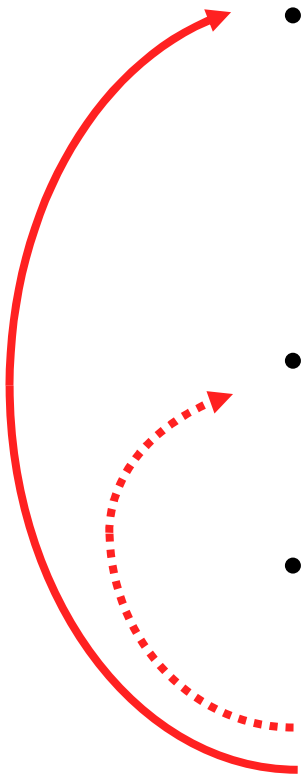
Constraints are Percolated Across the Derivation Tree

- Feature unification ($\sqcup$) at tree nodes
- Every tree of depth 1 is licensed by a grammar rule
- A feature can be assigned a value ($:=$)
- Two features can be constrained to have identical values ($=$)



The Interpreter is Based on the Context-Free Backbone of the Grammars

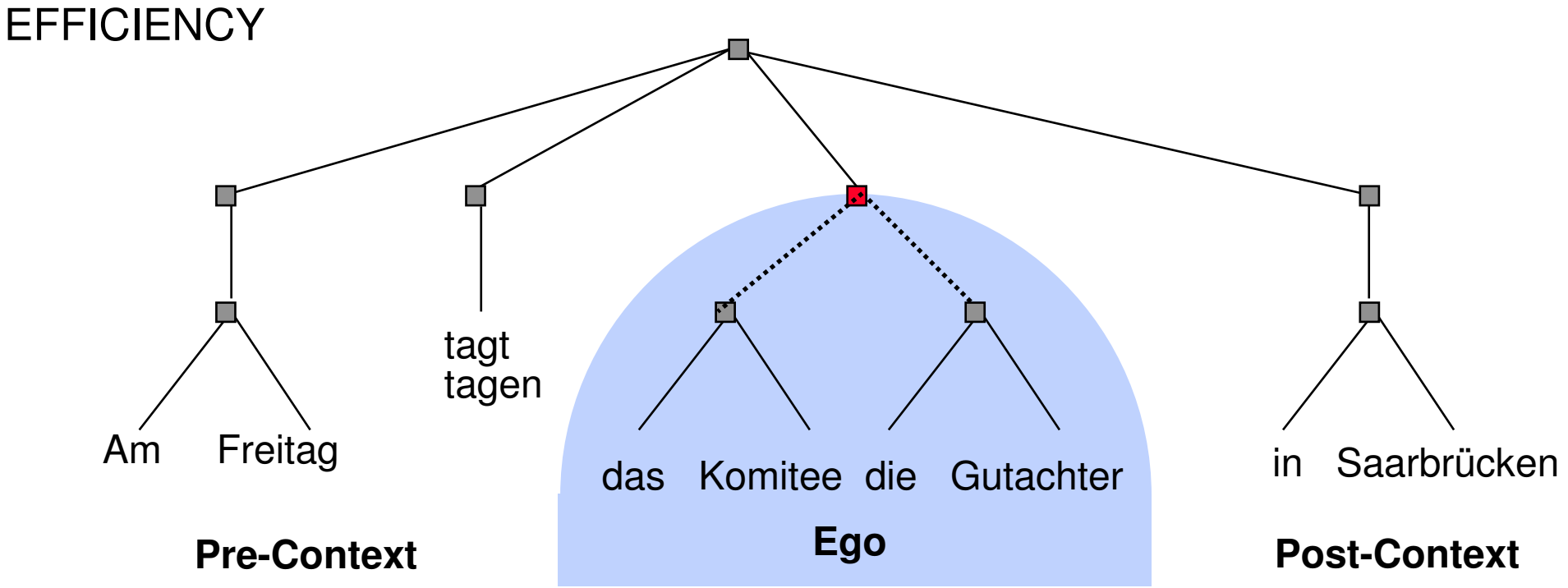
THREE-STEP EVALUATION CYCLE



- **Matching**
  - Identify all rules with the **current category**
  - For each of them perform its tests on the **input structure** (“IF” part)
  - Add those passing the tests to the conflict set
- **Conflict resolution**
  - Select an element of the conflict set (possibly by some preference mechanism)
- **Firing**
  - Evaluate the rule‘s constraints (if available, “WHERE” part)
  - For each element of the “THEN” part, read the new category and determine the new input structure by evaluating the associated access pointer

Source: Stephan Busemann

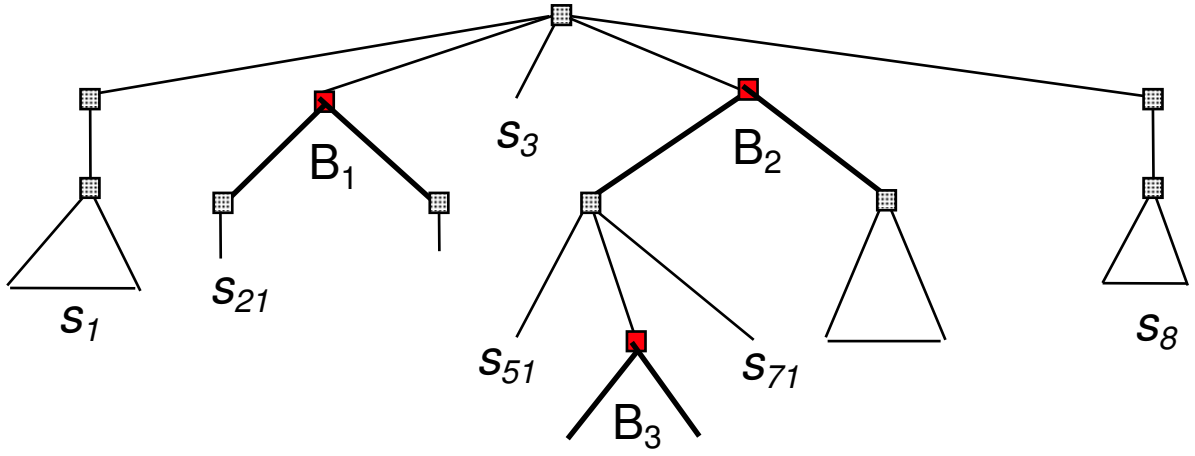
During Backtracking the Context is Re-Used



- ***Pre-* and *Post-Context* remain unchanged (modulo word inflection)**
  - Prerequisite: context-free skeleton of TG/2 Grammars
- ***Ego* must be generated from scratch every time (modulo memoisation)**

Each Two Backtrack Nodes Are Either Nested or in Parallel

MULTIPLE SOLUTIONS



	Pre-Context	***Ego***	***Post-Context***
B_1	s_1	$V_1 = \{ s_{2i} \mid 1 \le i \le \lvert B_1 \rvert \}$	$s_3 \cdot V_2 \cdot s_8$
B_2	$s_1 \cdot V_1 \cdot s_3$	$V_2 = \{ s_{4j} \mid 1 \le j \le \lvert B_2 \rvert \}$	s_8
B_3	$s_1 \cdot V_1 \cdot s_3 \cdot s_{5j}$	$V_3 = \{ s_{6k} \mid 1 \le k \le \lvert B_{21} \rvert \}$ wobei $s_{4j} = s_{5j} \cdot V_3 \cdot s_{7j}$	$s_{7j} \cdot s_8$

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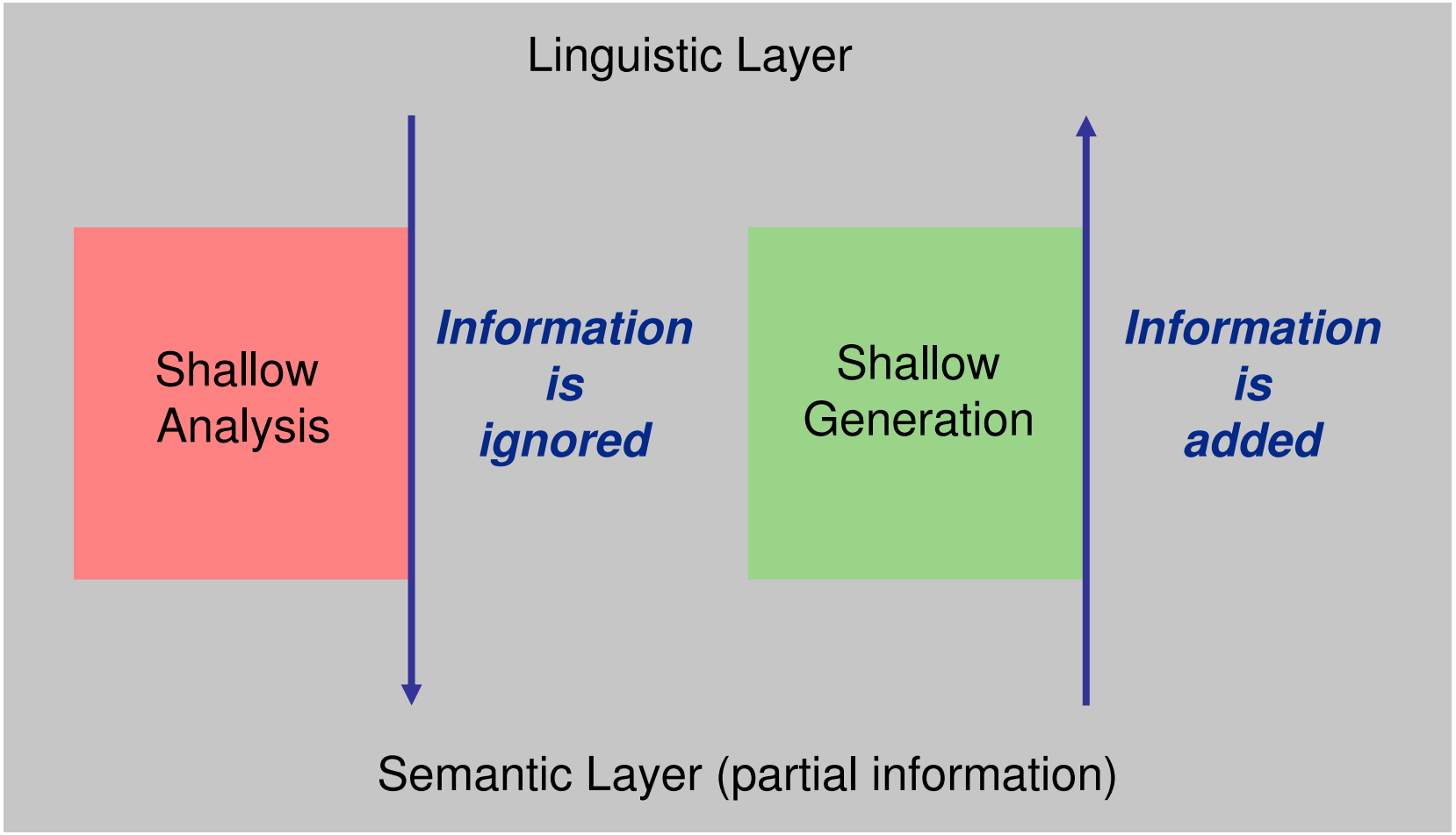
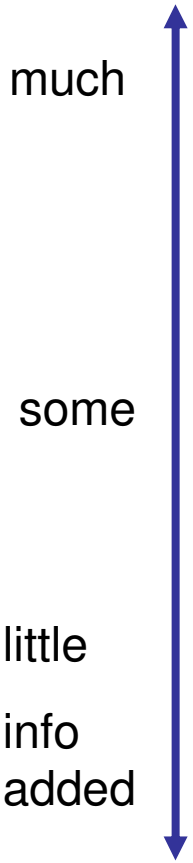
Shallow Processing Deals With Partial Information



Source: Stephan Busemann

Some Major Applications with TG/2

Shallowness / Domain dependence of grammar



TEMSIS – multilingual air quality reports (Busemann/Horacek 1998)

COMRIS – personalized recommendations in a conference scenario (Geldof 1999)

COSMA – appointment scheduling dialogue contributions (Busemann et al. 1994)

MUSI – syntactic realizer for medical scientific sentences (Lenci et al. 2002, Busemann 2002)

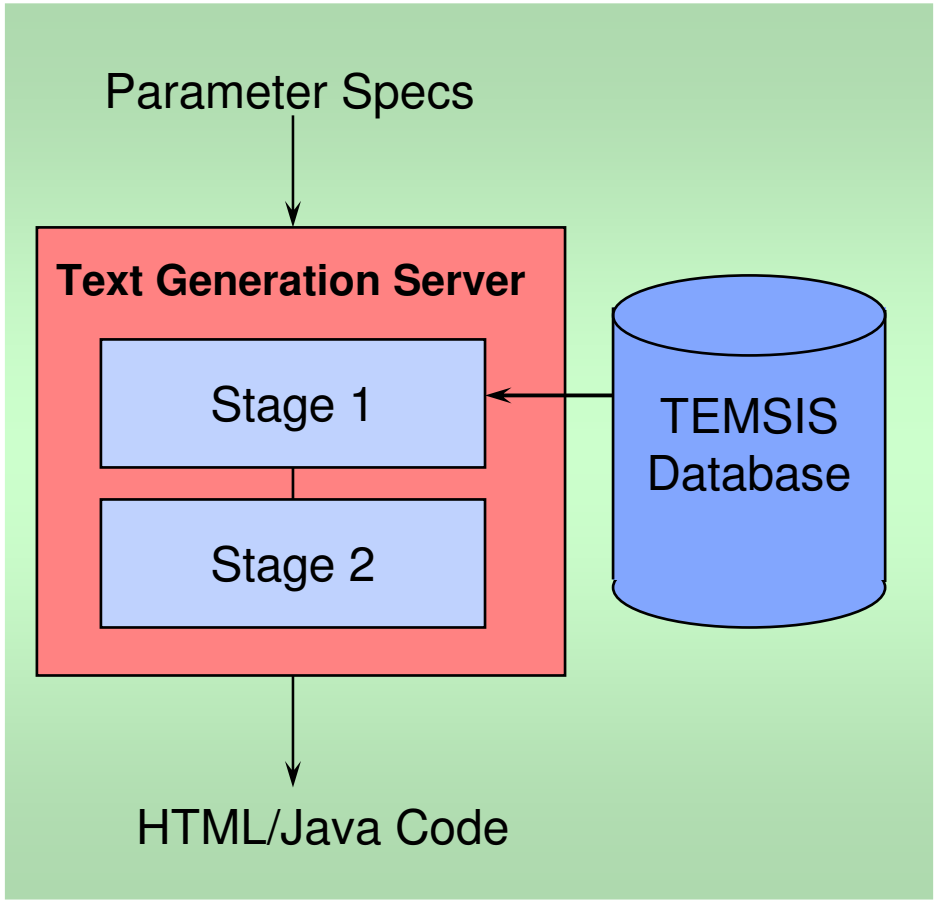
Depth / reusability of grammar

Source: Stephan Busemann

Text Generation in TEMSIS Occurs in Two Steps

GENERATION SYSTEM OVERVIEW

- **Parameter selection by the user**
  - language (D, E, F, P, C, J)
  - pollutant and measurement station
  - relevant period of time
- **Stage 1: Text schema construction**
  - querying the database
  - composition of report structure
  - elision of contextual redundancies
- **Stage 2: Linguistic realisation by TG/2**
  - selection of sentence patterns
  - wording, phrasing, grammar
- **HTML postprocessing**



Source: Stephan Busemann

The Texts Vary According to the User's Preferences

EXAMPLE

- **Parameters selected within the TEMSIS Navigator menus:**
  - French text about a German situation
  - ozone data, exceeding thresholds according to decree
  - measurements at Völklingen-City in summer 1997 (to be confirmed)

Vous avez choisi la station de mesure de Völklingen-City afin de consulter la pollution atmosphérique relevée en été 1997.

A la station de mesure de Völklingen-City, la valeur d'information pour l'ozone pour une exposition de 60 minutes (180 µg/m³ selon le decret allemand (Bundesimmissionsschutzverordnung)) a été dépassée une fois.

La valeur d'interdiction du trafic (240 µg/m³) a aussi été dépassée une fois.

En été 1996 la valeur d'information (180 µg/m³) n'a pas été dépassée .

Source: Stephan Busemann

The Reports Consist of Several Statements

SAMPLE SCHEMA FOR SUMMER OBSERVATION, THRESHOLD PASSING

- **Confirm pollutant, measurement station, and time interval**
- **Number the values exceeding the lowest threshold**
- **Number the values exceeding the next threshold**
- **Compare with values of preceeding year**
- **Repeat the core statement („Summary“)**

A schema is computed on the basis of the input parameters and the retrieved data

Source: Stephan Busemann

Instantiating a Schema Leads to a Report Structure

TEXT ORGANISATION

- **Achieves text coherence by**
  - removing redundant information
  - inserting particles („also“)
  - simple techniques of aggregating information
- **Yields canned texts or intermediate content representations**
- **Intermediate representations are independent of particular languages**
  - TG/2 generates German, French, English, Portuguese, Chinese and Japanese text from them

Shallow generation can do without explicit knowledge representation and text planning

Source: Stephan Busemann

Non-Linguistic Input for Air Quality Report Generation in TEMSIS

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Source: Stephan Busemann

Multilingual Generation in TEMSIS

- **Grammar size about 100-120 rules**
- **Written with standard text editors (emacs)**
- **Six languages: German, French, English, Chinese, Japanese, Portuguese**
- **Grammar is the only language-specific part** (except for canned texts about pollutants etc and error messages)
- **Adding a new language required little effort: 2-4 weeks, depending on skills** (incl. getting familiar with the system)
- **http://www.dfki.de/service/nlg-demo**

Source: Stephan Busemann

Generated Texts Are Not Invented

CORPUS-BASED GRAMMAR DEVELOPMENT (REITER)

- **User provide examples for target texts - the more, the better**
  - Texts produced manually by domain experts
- **Initial analysis of user-generated corpus**
  - Identify the knowledge used by the authors
  - Clarify with users any underlying semantic and rhetoric relationships
  - Discuss with users how the texts can be improved
- **Analysis of the revised corpus**
  - Definition of linguistic coverage
  - Correlate surface chains and underlying relations
  - Test of revised corpus (Wizard of Oz) and iterate the whole process, if necessary
- **Generalisation from Corpus Samples to Prototypical Examples (Templates)**
  - Basis for shallow grammar development

Source: Stephan Busemann

Shallow TG/2 Grammars Depend on the Domain

- **Most NLG system cannot cope with varying input**
  - Linguistic vs non-linguistic
  - Course-grained vs fine-grained semantic specifications

- **TG/2 grammars usually are domain-dependent**
  - The input was domain-dependent
  - Grammar development was cheap (~150 rules, ~20 lexemes)

- **In-depth applications require a more generic approach**
  - MUSI IRep4 is a general representation language based on FOL
  - Grammar development had to start before IRep4 was stable
  - Coverage requirements are considerably higher (>800 rules, ~2.000 lexemes)
  - TG/2 grammar editor eGram to improve maintainability

Source: Stephan Busemann

MUSI Deals with Cross-Lingual Summarisation, Combining Rule-Based and Statistical Techniques

- **"Ideal" approach**
  - conceptual analysis → conceptual summarisation → NL generation
- **Real world situation**
  - Incomplete knowledge, incomplete analysis results,
  - Available technical bases: statistics, cue-phrases, cut-and-paste, concepts
- **MUSI combines different techniques**
  - Filter extracted material based on weighting, cue-phrases and position
  - Deep (conceptual) analysis of the extracted sentences only
    - **The result can be under-specified**
  - Generation of extracted material in target language has to cope with fragmentary input

Source: Stephan Busemann

Query-Based Summarization

1 TRANS-ESOPHAGEAL ECHOCARDIOGRAPHY IN CRITICAL PATIENTS

Bedside transthoracic and transesophageal echocardiography is a powerful diagnostic tool, in our experience accurate diagnosis can lead to prompt surgical treatment of life threatening lesions like pericardial effusion and tamponade, intra atrial tumor masses, valvular and prosthetic endocarditis, aortic dissection..
Blunt chest trauma may cause many different lesions of the heart and blood vessels: myocardial contusion, traumatic pericarditis, occlusion of a coronary vessel, papillary muscle rupture, inter ventricular septum defect, tricuspid regurgitation, traumatic aortic transection.
We describe our experience in emergency area, either in dedicated to cardiac surgery intensive care unit or operative room either in general emergency and intensive care unit.
From 1994 we examined with bedside transthoracic and transesophageal echocardiography patients with blunt chest or thoracic-abdominal trauma and patients with head trauma possible transplant organ donors.
Moreover, since ours is a regional reference Center, we received emergency patients with traumatic lesions from other Hospitals. From January 1st 1994 to October 31st 1996 we examined 158 patients in the General Intensive Care (37 with trauma, 45 transplant organ donors, 5 post cardiopulmonary resuscitation and 71 for miscellaneous); in the same time we accepted 11 patients (7 M) mean age 37 yr.. (12-73) for suspect traumatic lesion of the heart and great vessels. Ten patients were operated: two had pericardial effusion, six underwent aortic surgery with interposition of dacron prosthesis and in one instance repair of aorta-right atrium fistula.

> lesions of the heart?

customisable length,
query-relevance, cue-phrases

<feedback>HIGH RELEVANCE</feedback>

Bedside transthoracic and transesophageal echocardiography is a powerful diagnostic tool, in our experience accurate diagnosis can lead to prompt surgical treatment of life threatening lesions like pericardial effusion and tamponade, intra atrial tumor masses, valvular and prosthetic endocarditis, aortic dissection..

Blunt chest trauma may cause many different lesions of the heart and blood vessels: myocardial contusion, traumatic pericarditis, occlusion of a coronary vessel, papillary muscle rupture, inter ventricular septum defect, tricuspid regurgitation, traumatic aortic transection.

Type A aortic dissection patients are accepted on emergency and examined with TEE just after induction of anesthesia to confirm diagnosis and involvement of aortic valve to allow conservative surgery: the technique is useful but the possibility of pitfalls must be considered.

Source: Stephan Busemann

Sentence Extraction is Parameterized by Weights

- **Basic idea: assign each sentence a weight**
  - based on its position and relevance wrt cue phrases or query
- **Select sentences with the highest weights**
  - above a given threshold
  - up to a given number

Computation of the weight for a sentence S

weight (S) =
k1*position(S) + k2*cue_phrases(S) + k3*query_relevance(S)

“Protogrammars” Can be Developed Quite Independently of Input Languages

- **Protogrammars are developed for the bookshelf**
  - Application Grammars are derived by defining tests and access functions once an input language definition is available
  - Re-usability is largely increased
- **Protogrammars lack test predicates and access functions**
  - Independent on input
  - One lexeme per PoS and per syntactic subcategory
  - Testable without specific input (except for prohibition of recursion)
- **Protogrammars can be combined in a modular way**
  - Genre dependence
  - Coverage requirements
  - Lexicon

Source: Stephan Busemann

Language-Neutral Representation for Translating Medical Scientific Text in MUSI

```
PROP{ Value = P_ARG1_cause_ARG2;
      Time_Rep = [PRESENT, PRES_USUAL];
      Cat = V_SEN;
      Arg1 = PROP{ Value = P_antagonism_with_ARG1;
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                   Arg1 = ITEM{ Value = C_acetylcholine;
                                Mod1 = [LOC, ITEM{
                                        Value = C_level;
                                        Det = DEF;
                                        Mod1 = [RESTR, ITEM{
                                                Value = C_sight;
                                                Number = PLUR; Det = DEF;
                                                Mod1 = [RESTR, C_muscarinic];
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                                                        Value = C_substance;
                                                        Number = PLUR;
                                                        Det = DEMONST1;}]; }]; }]; };
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The effects are caused by a competitive antagonism with acetylcholine at the level of the muscarinic sights of these substances.

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                   Arg1 = ITEM{ Value = C_acetylcholine;
                                Mod1 = [LOC, ITEM{
                                        Value = C_level;
                                        Det = DEF;
                                        Mod1 = [RESTR, ITEM{
                                                Value = C_sight;
                                                Number = PLUR; Det = DEF;
                                                Mod1 = [RESTR, C_muscarinic];
                                                Mod2 = [RESTR, ITEM{
                                                        Value = C_substance;
                                                        Number = PLUR;
                                                        Det = DEMONST1;}]; }]; }]; };
                   Mod1 = [RESTR, C_competitive]; };
      Arg2 = ITEM{ Value = C_effect;
                   Det = DEF; Number = PLUR; }; }
```

The effects are caused by a competitive antagonism with acetylcholine at the level of the muscarinic sights of these substances.

Language-Specific Input to TG/2 (German)

```
[(SENTENCE DECL)
 (VC [(VOICE PASSIV) (MOOD IND) (TENSE PRAESENS) (SBP S2)
      (STEM "verursach")])
 (DEEP-SUBJ [(TY GENERIC-NP)
             (NUMBER SG) (DET INDEF) (NR V2) (GENDER MAS)
             (STEM "antagonismus")
             (PP-ATR [(PREP MIT) (DET WITHOUT) (NUMBER SG) (GENDER NTR)
                      (STEM "Acetylcholin")
                      (LOCATIVE ...)])
             (ADJ [(STEM "kompetitiv")
                   (POS ADJECTIVE) (DEG POS)])])
 (DEEP-AKK-OBJ [(TY GENERIC-NP)
                (NUMBER PLUR) (DET DEF) (GENDER FEM)
                (STEM "wirkung")])]
```

Die Wirkungen werden durch einen kompetitiven Antagonismus mit Acetylcholin ... verursacht.

Source: Stephan Busemann

Language-Specific Input to TG/2 (German)

```
[(SENTENCE DECL)
 (VC [(VOICE PASSIV) (MOOD IND) (TENSE PRAESENS) (SBP S2)
      (STEM "verursach")])
 (DEEP-SUBJ [(TY GENERIC-NP)
             (NUMBER SG) (DET INDEF) (NR V2) (GENDER MAS)
             (STEM "antagonismus")
             (PP-ATR [(PREP MIT) (DET WITHOUT) (NUMBER SG) (GENDER NTR)
                      (STEM "acetylcholin")
                      (LOCATIVE ...)])
             (ADJ [(STEM "kompetitiv")
                   (POS ADJECTIVE) (DEG POS)])])
 (DEEP-AKK-OBJ [(TY GENERIC-NP)
                (NUMBER PLUR) (DET DEF) (GENDER FEM)
                (STEM "wirkung")])]
```

Die Wirkungen werden durch einen kompetitiven Antagonismus mit Acetylcholin ... verursacht.

Source: Stephan Busemann

Realization of German Sentences in MUSI

- **Size of hand-written grammar: about 950 rules**
- **Written with standard text editors (emacs), then dedicated editor eGram**
- **CFGs do not support encoding of word order variation etc.**
- **Metarule formalism within eGram (Rinck 2003)**
- **Size of derived grammar about 2.500 rules**
- **Processing slows down with huge conflict sets**
- **Take decisions on sentence structure and lexical choice outside of TG/2**

Performance loss on backtracking is low

Size of grammars and conflict sets matter

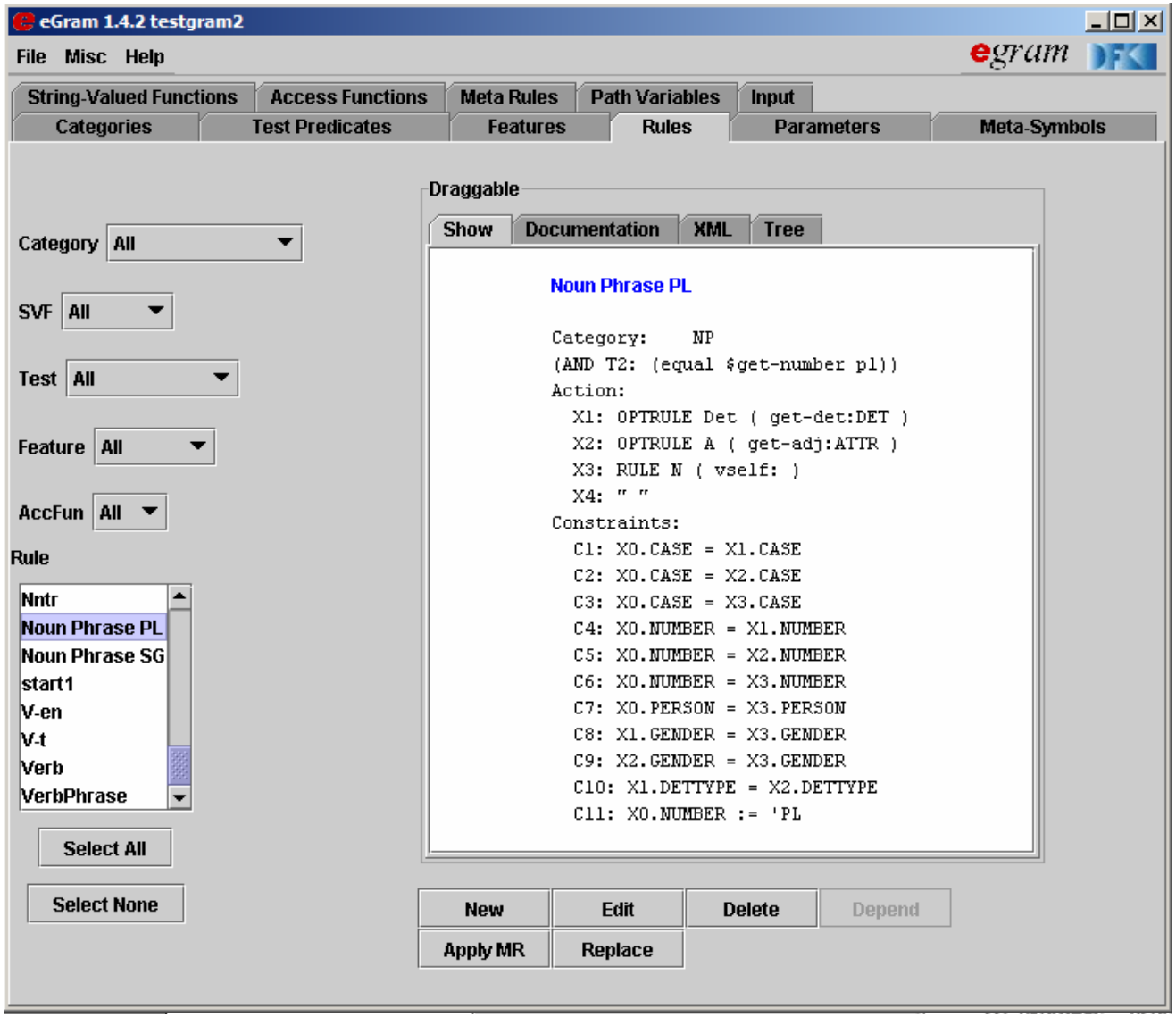
Source: Stephan Busemann

Overview

- Motivation
- The TG/2 NLG framework
- Some major applications
- Modifications and extensions
- Assessment and conclusions

eGram Supports Grammar Development

- Developer-friendly grammar format
- Syntactic and semantic checks of grammar knowledge
- Optionally derive rules from metarules
- Integration with testing by TG/2 and XtraGen



Source: Stephan Busemann

Declarative Input/Grammar Interface

- **XtraGen (Stenzhorn 2002), a Java brother implementation**
- **eGram (Busemann 2004), a rule editor for TG/2 style grammars, or CFG**

```
My category is DECL.
IF the slot COOP is 'threshold-passing
   AND the slot LAW-NAME is specified
THEN apply PPtime from slot TIME
     apply THTYPE from CURRENT-INPUT
     utter "("
     apply LAW from slot LAW-NAME
     utter ") "
     apply EXCEEDS from slot EXCEEDS
     utter "."
WHERE THTYPE AND EXCEEDS agree in GENDER
```

- **Boolean test predicates**
  - To be defined in Lisp and Java
  - Based on built-ins
  - Automatic integration
- **Access pointers**
  - Pathnames rather than functions

Source: Stephan Busemann

Rule Selection Can Be Guided by Dedicated Conflict Resolution Strategies

- **Processing can be influenced wrt**
  - Selection of the next element of the conflict set
  - Selection of the next backtrack node
- **Conflict resolution strategies are defined by preferences**
  - Preferences correspond to TG/2 rules
  - Preferences can be weighted
- **Incremental generation of the best solution**
  - Based on local decision making
  - "hill-climbing" problem *[Nilsson 1980]*

Mutual dependencies of criteria can be learned

Examples for preferences

- Active (rather than passive)
- paratactic style
- German
- indexical (rather than anaphoric) temporal expressions
- formal style
- Expert jargon

Explicit Conflict Resolution in TG/2 is Based on User-Defined Parameters

EXAMPLE: GENERATION OF AIR QUALITY REPORTS

- **Addressees of the air quality reports**
  - Environmental administrations, usually expert users
  - General public, usually novice users
- **Text properties according to corpora**
  - Expert: jargon, technical terms, implicit understanding of relations between e.g. decrees and threshold types
  - Novice: no jargon, circumscribing technical terms, more explicit descriptions

The need for hyper-links became obvious in either case

Parameter		
Expertise	expert	novice
Hyperlink	*yes*	*no*

Source: Stephan Busemann

Parameterised, Alternative TG/2 Rules Yield Different Texts

- TG/2 Rules are annotated with possible parameter values
- The user decides which values apply
- The conflict resolution procedure prefers those rules, whose annotations correspond best to the user preferences

- Expertise: expert
  - **In summer 1997, the information value for ozone (180 µg/m³ according to the German decree Bundesimmissionsschutzverordnung) has been exceeded once.**
- Expertise: novice
  - **Between April and September 1997, the lowest threshold for ozone called information value, which is at 180 µg ozone per m³ air, has been exceeded once.**

Source: Stephan Busemann

Personalized Text Generation (Busemann 1998)

- **Assign preferences to rules**
- **From a conflict set, preferred rules are selected next**
- **Define hierarchy of preference features**

Assign rules with

Expertise: expert | non-expert

Background: + | -

User selects non-expert, +

Conflict set {R1, R2, R3}

R1: expert, -

R2: non-expert, -

R3: expert, +

Expertise > Background **-> R2**

Background > Expertise **-> R3**

Source: Stephan Busemann

Overview

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TG/2 is a Single Pass Mapper

- **TG/2 is often combined with other systems**
  - TEMSIS: Text structuring depending on database content; TG/2 generating at paragraph level
  - MUSI: Lexicalization and syntactic choice, avoiding huge conflict sets in TG/2; TG/2 as sentence realizer
- **RAGS pipeline not possible in one pass**
  - Pipelining multiple TG/2 instances?
- **For interdependencies between subtasks, as in micro-planning, the rule set must spell out all alternatives and quickly becomes unwieldy**

Source: Stephan Busemann

Shallow Generation Has Pros and Cons

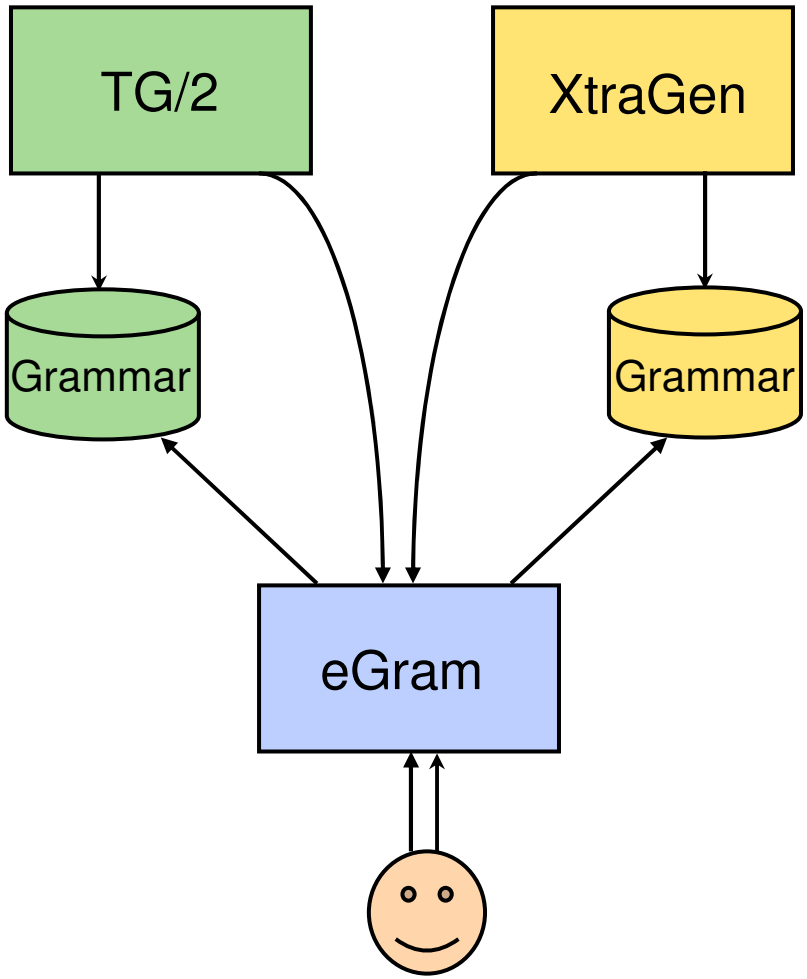
ASSESSMENT

Possible advantages	Possible drawbacks
• Low development effort • Reusable interpreter and subgrammars • Very fast processing • Easy introduction of additional languages • Easy extension with alternative formulations (through a preference mechanism in TG/2)	• Knowledge representation depends on application • Implicit dependencies • Scalability is inherently lower than with in-depth generators • Maintaining transparency of grammars can become a cost factor

Source: Stephan Busemann

Conclusions

- TG/2 is a framework that can implement shallow NLG tasks as well as in-depth realization
- Grammar writing for TG/2 and XtraGen is supported by eGram
- TG/2 has been licensed to more than 30 sites for commercial, educational and research purposes



Source: Stephan Busemann

Questions Answered by Slideset

- How does shallow generation differ from (standard) in-depth generation?
- Give advantages and disadvantages of shallow generation.
- How are sample corpora used to ensure the required coverage is available and the correct wordings are generated?
- Should an NLG problem be addressed using clause-length pieces of prefabricated text with gaps to be filled during generation? Justify your decision considering both the complexity of the problem and the complexity of the generation process.

Source: Stephan Busemann