ARGUMENTATION
Internal (Execution) Language for Cognitive Programming

- The Logic of Argumentation
  - Argumentation Logic
- Argumentation for Common Sense Reasoning
  - Argumentation for Cognitive Systems
- An Argumentation Framework
  - **Logic Programming with Priorities (LPP)**
  - **GORGIAS system for LPP**

Σημασιολογία Γοργία
Επιχειρηματολογία

- Λογική Επιχειρηματολογίας
  - Κάθε σύνολο κανόνων αποτελεί ένα επιχείρημα για τα (λογικά) συμπεράσματα που στηρίζει.
  - Επιχειρήματα που στηρίζουν αντίθετα συμπεράσματα αντικρούονται μεταξύ τους.
  - Ποιο επιχείρημα υπερισχύει?

Argumentation - Outline

- What is a "good" argument?

- Formalizing Argumentation – Abstract
- Formalizing Argumentation – Realization

- Application Examples
- Argumentation-Based Agent Deliberation

- Argumentation for Cognitive Systems

Introduction - General

- Argumentation
  - Role of argumentation in natural human reasoning and dialogue studied in philosophy, linguistics, psychology, communication studies.
    - Example: Recent paper (2011) of Mercier and Sperber
  - Argumentation logics formalise defeasible reasoning as construction and comparison of arguments
    - Reasoning with incomplete and conflicting information
  - Argumentation theory in AI for autonomous agents, analytics of online debates, cognitive policies and systems

Introduction – An Example

Given the Common Sense Knowledge:

(r1): fly(x)←bird(x)
(r2): ¬fly(x) ←penguin(x)
(r3): penguin(x) ←walkslikepeng(x)
(r4): ¬penguin(x) ← ¬flatfeet(x)
(r5): bird(x) ← penguin(x)
(r6): bird(T)
(r7): walkslikepeng(T)
(r8): ¬flatfeet(T)

with the priorities r2>r1, r4>r3

? fly(T)

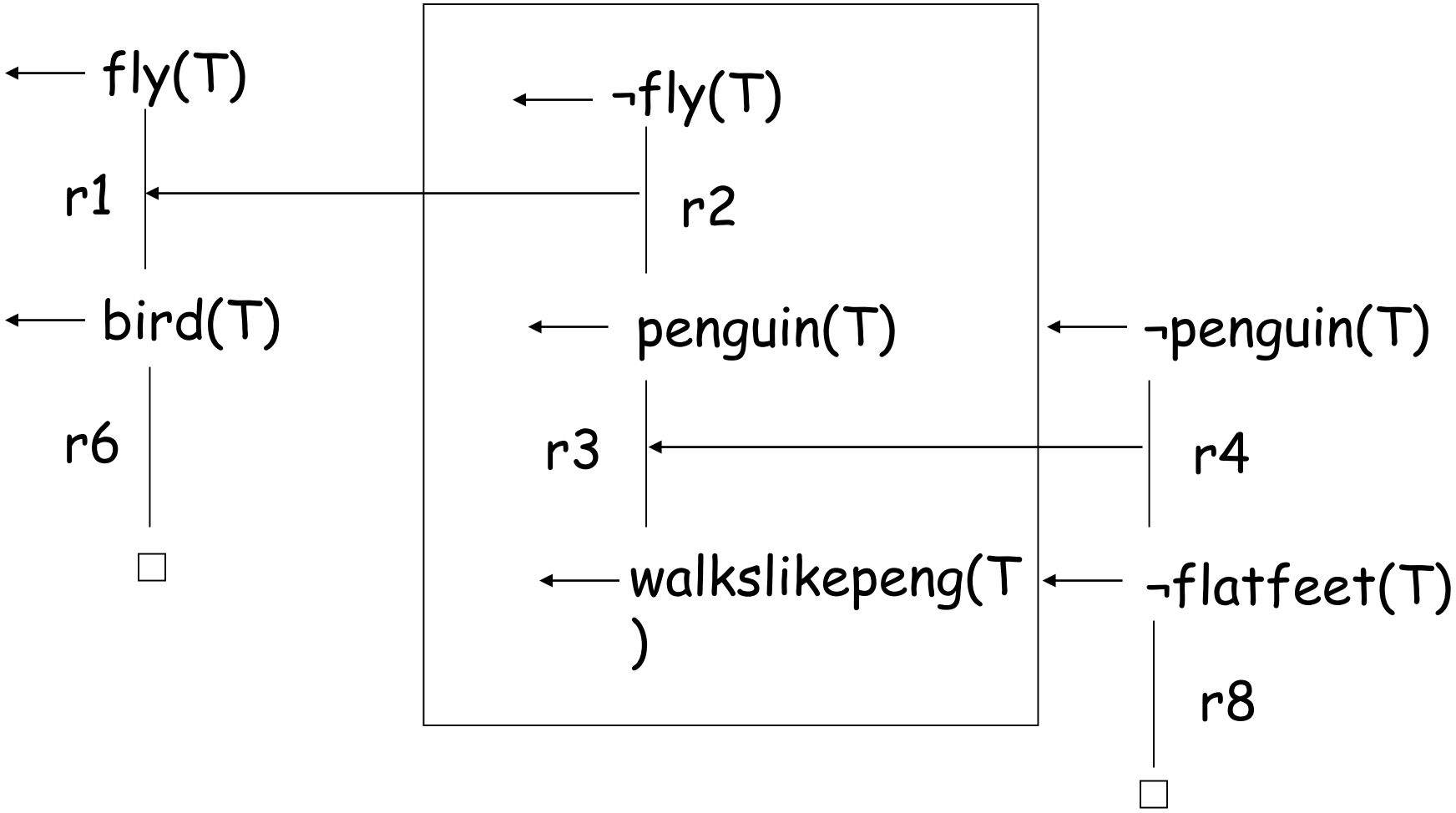
Argument for:
A1 ={r6, r1}

Against A1:
A2 ={r7, r3, r2}

Against A2:
A3 = {r8, r5}

Yes, fly(T) can be supported by {A1, A3}

Dialectic Process of Argumentation



Introduction – Another Example

- What is a good argument? - EXAMPLE
  - Position: Attend this talk
  - Arg: This is the reason we came to the conference
  - C-Arg1: The speaker is known to be boring
    - But the title of the talk is interesting – **Separate Defence**
  - C-Arg2: A friend wants to meet (for coffee I think)
    - But my sense of professional responsibility is generally stronger than that of self satisfaction - **Arg is Stronger than C-Arg2**
  - C-Arg2': The friend is not well and wants help
    - My sense of social responsibility is generally stronger than professional responsibility - **Arg is Weaker than C-Arg2'**
    - I have been assigned to write up a report on this afternoons talk

      --Argument for social resp. is weaker than that of professional resp.

      -- Hence, Arg is Stronger than C-Arg2

Semantics of Argumentation

- **What is a good argument?**
  - An argument that builds a **coherent case** for its position.
    - **Δένει καλά μαζί!**
  - An argument that can defend itself against all its counter-arguments
  - An argument that renders its counter-arguments incoherent
- **An argument that has some kind of a stable property in the space of all available arguments**

Semantics of Argumentation

- What is a good argument?
  - An argument that can defend itself against all its counter-arguments
    - Admissible arguments
- Admissibility can be generalized (see later)

Abstract Argumentation (1)

- An abstract argumentation framework is a pair of a set T of arguments and an attacking relation on arguments
  - AF=<T, Att>, where Att is a binary relation on T

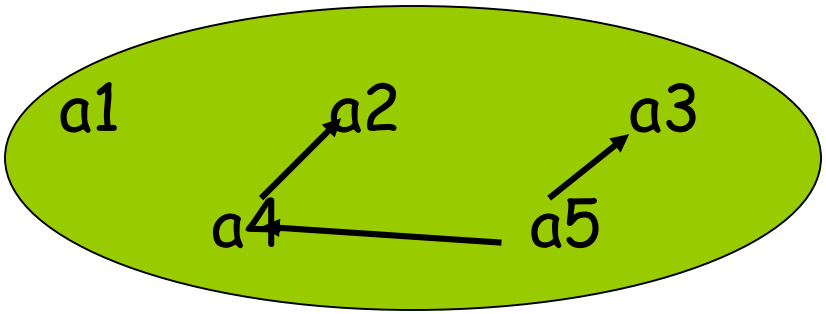
- S⊆T is an Admissible Argument iff
  - S it does not attack itself (i.e. it is conflict free), and
  - S attacks (counter-attacks) all its attacks

- This is a simple but powerful definition.

Abstract Argumentation (2)

- S⊆T is an Admissible Argument iff
  - S it does not attack itself (i.e. it is conflict free), and
  - S attacks (counter-attacks) all its attacks

- Example



  - {a2} and {a3} are not admissible.
  - But {a2,a5} is admissible.
  - {a1}, {a5} are admissible.
  - {a1,a2,a5} is maximally admissible.

Argumentation Basics
(Dung, Kakas, Kowalski, Mancarella,Toni)

- An argument is:
  - A set of sentences/rules, S, in some background logic (L, $\vdash$): from which we can derive a conclusion (I.e. S$\vdash\phi$)
- Attacking Relation:
  - Specifies when one argument (i.e. a set S_1 of rules) attacks another argument S_2 e.g. when:
    - they have some contrary conclusion and S_1 is "as strong" as S_2.
- Admissibility/Acceptability criterion:
  - Selects appropriate arguments (from a given corpus), called admissible/acceptable, that "behave well" under their attacks
- An argument S is Admissible:
  - S is conflict free (i.e. it does not attack itself) and
  - S attacks (counter-attacks) all its attacks
- Credulous or Skeptical Reasoning:
  - A conclusion holds in one or all admissible/acceptable extensions

Argumentation Realization

STEP 1

- **Structured argumentation**
  - How are arguments constructed?
  - How is conflict and attack between them recognized?
- **Preference based argumentation**
  - The attacking relation is defined in terms of a priority on the structure on the arguments.

Preference Based Argumentation (Informal Presentation)

- **How do we construct an argumentation framework?**
  - **Support a decision via an admissible argument S:**
    - **S is consistent**
    - **S refutes every counter-argument**
    - **S is consistent**
    - **S attacks all its attacks**
- **What is an attack?**

Preference Based Argumentation (2)

- **What is an attack on S_1?**
  - **An argument S_2 with contrary claims (either for the original top-level decision or for the supporting ones)**
  - **Where S_2 is also NOT less preferable.**
- **What is "less preferable"?**
  - **Contains weaker components (links)**
- **What is a "weaker component/link"?**

Preference Based Argumentation (3)

- **What is a "weaker component/link"?**
  - **This is stated explicitly in the theory/knowledge, eg.**
    - "Social responsibility is stronger than personal gain"
    - "Later laws are stronger than earlier ones"
    - "Later events have stronger information than earlier ones"
    - "Specific information is stronger than general information"
  - **LOCALLY specified and lifts via the argumentation to give GLOBAL (overall preferred) decisions.**

=> **MODULARITY of Knowledge Representation**

=> **MODULARITY of Design and Architecture of Cognitive Systems**

Preference Based Argumentation (4)

- **What is a "weaker component/link"?**
  - **This weaker/stronger notion is not fixed conditional e.g.:**
    - **"A law is stronger than another WHEN this is passed later"**
    - **"Accepting a requested task is stronger than carrying out your own task WHEN the request comes from a superior"**
  - **This dynamic nature of preferences/attacking is vital in a changing environment**
    - **Adaptability of argumentative reasoning – change its decisions**

Argumentation Realization
STEP 2

- Realizations in a logical framework
- An argument is a set of sentences to support a conclusion in some background monotonic logic $(\mathcal{L}, \vdash)$:
  - AF = <T, Att>, where T is a theory in some logic
  - Given a subset of sentences S we can derive conclusions ($S \vdash \phi$)
    - **These conclusions are the positions of the argument**

The Attacking Relation

Specifies when a subset S_1 (of the given theory T) attacks another subset S_2 (e.g. when they derive contrary conclusions)

An attacking relation is realized via:

1) Inconsistent conclusions
2) A local Priority Relation (<):
   - Encodes locally the relative strength of sentences/rules in the theory: r<r′ means that r has lower priority than r′.
   - This lifts up to a global strength relation on arguments
   - It can be reasoned, just like any other predicate, and thus it can be classified as either static or dynamic and first- or higher-order.

- Strength Relation via Priorities:
  - $\phi \preceq_{DYN} \psi$ iff $(\exists r \in \phi, r' \in \psi : \phi \vdash r' < r) \Rightarrow (\exists r \in \phi, r' \in \psi : \psi \vdash r < r')$

The Attacking Relation

- An attacking relation is realized as:

  1) ϕ and ψ have a contrary conclusion

  2) Strength Relation via Priorities:
  - $\phi \preceq_{DYN} \psi$ iff $(\exists r \in \phi, r' \in \psi : \phi \vdash r' < r) \Rightarrow (\exists r \in \phi, r' \in \psi : \psi \vdash r < r')$

  Then Att(ψ, ϕ), i.e. ψ attacks ϕ.

- Strong and Weak attacks.

Basics of the Argumentation Framework

- Extension of LPwNF with dynamic priorities and attacking relation
- An argument is tuple $(\mathcal{T}, \mathcal{P})$ where $\mathcal{P}$ gives priorities to the rules in $\mathcal{T}$
- (Extension) of the admissibility semantics

Agent application: roles and context define the dynamic nature of the attacking relation

Logic Programming without Negation as Failure (LPwNF)

- **Horn background logic**:
  - Rules: $L \leftarrow L_1, \ldots, L_n$ where $L, L_1, \ldots, L_n$ literals $L_i = (\neg)A_i$
  - Contrary given by classical negation $\neg$
  - Priority relation ">" on rules of the theory

Example

$p \leftarrow q$, not r "p holds if q holds unless r holds"

R_1: $p \leftarrow q$
R_2: $\neg p \leftarrow r$
$R_2 > R_1$

- Attacking relation given by:
  - S attacks S' iff there exist L and $S_1 \subseteq S$, $S'_1 \subseteq S'$ s.t.:
    - $B \cup S_1 \vdash_{min} L$ and $B \cap S'_1 \vdash_{min} \neg L$
    - $S_1 \supseteq S'_1$ (If S_1 has a rule of lower priority then it also has one of higher priority)

Applications of Argumentation

Default (Hierarchical) Reasoning (Static Priorities)

f1: bird(tweety).

f2: penguin(tweety).

r1(X): fly(X) $\leftarrow$ bird(X).

r2(X): $\neg$ fly(X) $\leftarrow$ penguin(X).

r3(X): r1(X) < r2(X).

- {f2,r2(tweety),r3(tweety)} is an admissible set (since its only conflicting argument {f1,r1(tweety)} does not qualify as an attack.)

- {f1,r1(tweety)} attacks {f2,r2(tweety)} but when we include r3(tweety) in the latter it does not.

Example: Legal Reasoning

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ucc: perfected ← possesion.

sma: ¬ perfected ← ship, ¬ finstatement.

- Basic facts:

  f1: possession.

  f2: ship.

  f3: ¬ finstatement.

  f4: newer(ucc,sma).

  f5: federal_law(sma).

  f6: state_law(ucc).

- Lex Posterior and Lex Superior

  lex_posterior(X,Y): Y < X ← newer(X,Y).

  lex_superior(X,Y): X < Y ← state_law(X), federal_law(Y).

- Higher-Order Priority

  r1(X,Y): lex_posterior(X,Y) < lex_superior(X,Y).

Temporal Reasoning (Frame Problem)

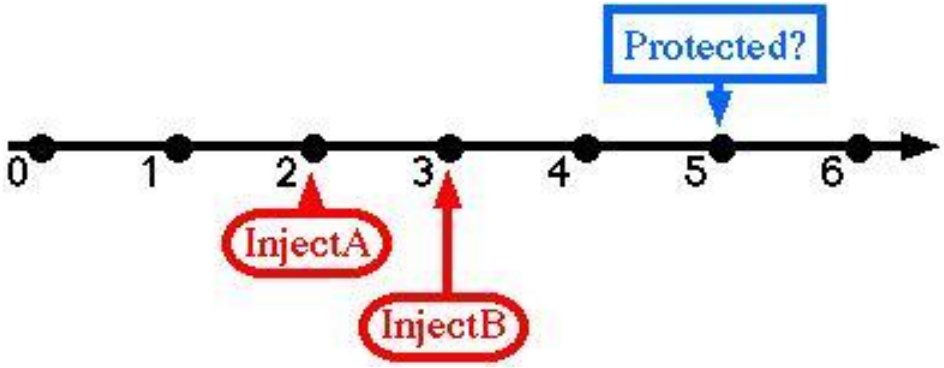
- **Arguments in A** are:
  - **generation rules:**
    - holds $(F,T_2) \leftarrow$ initiation(F,T_1), $T_1 < T_2$
    - $\neg$ holds $(F,T_2) \leftarrow$ termination (F,T_1), $T_1 < T_2$
  - **persistence rules:**
    - holds $(F,T_2) \leftarrow$ holds (F,T_1), $T_1 < T_2$
    - $\neg$ holds $(F,T_2) \leftarrow \neg$ holds (F,T_1), $T_1 < T_2$
  - **assumption rules:** holds (F,T), $\neg$ holds (F,T)

- **Priority <** is given by:
  - **persistence rules <** later(or =) & conflicting **generation rules**
  - **generation rules <** later & conflicting **generation rules**
  - **assumptions <** conflicting **generation rules**

Example

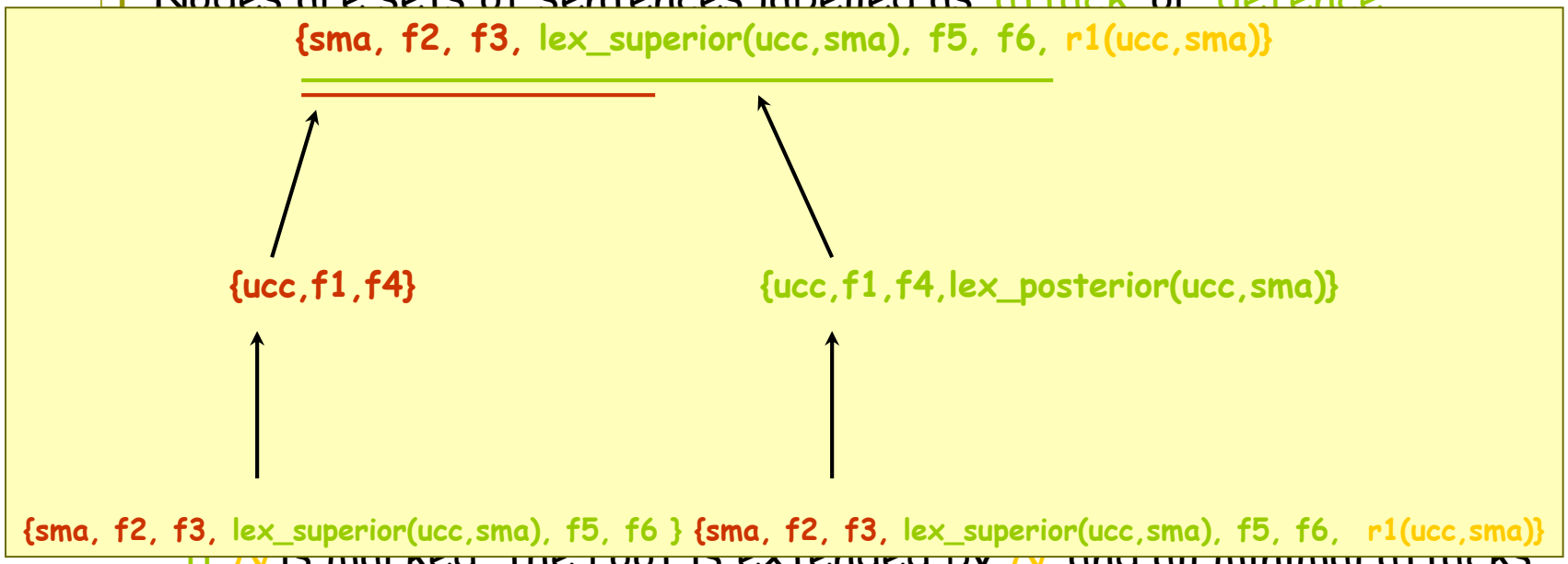
- InjectA initiates Protected when {TypeO}
- InjectB initiates Protected when {¬TypeO}

- ¬Protected holds-at 0
- InjectA happens-at 2
- InjectB happens-at 3



Computing Argumentation

- Construction of admissible trees via derivation of partial trees.
  - Nodes are sets of sentences labelled as 'attack' or 'defence'



  - N is marked, the root is extended by N, and all minimal attacks against N are added as additional unmarked attack nodes children of the root.
- Soundness and Completeness

An Example of Argumentation Theory Policy

- Decision policy of a seller agent

r1: sell(Prd, Ag, high-price) ← pay-card(Ag, Prd)
r2: sell(Prd, Ag, high-price) ← pay-install(Ag, Prd)
r3: sell(Prd, Ag, low-price) ← pay-cash(Ag, Prd)
r4: ¬sell(Prd, Ag, P2) ← sell(Prd, Ag, P1), P2≠P1

  - Priority: r1 > r2, r1 > r3 , r2 > r3

Argumentation with Roles and Context

- **Default Context**↔definition of roles
  - Market: normal, regular customer
- **Specific Context**
  - High season, sales season
- **Example Agent theory: T=($\mathcal{T}$, $\mathcal{P}_{\mathcal{R}}$, $\mathcal{P}_{C}$)**

  R1: h-p(r1(Prd, Ag), r3(Prd, Ag))

  R2: h-p(r3(Prd, Ag), r1(Prd, Ag)) ← regular(Ag), buy_2(Ag, Prd)

  R3: h-p(r3(Prd, Ag), r1(Prd, Ag)) ← regular(Ag), late_del(Ag, Prd)

  C1: h-p(R1(Prd, Ag), R2(Prd, Ag)) ← high-season

  C3: h-p(R2(Prd, Ag), R3(Prd, Ag)) ← special-product(Prd)

- MODULARITY of representation

Argumentation for Cognitive Assistants

- A Cognitive Assistant has two theories of argumentation:
  - TACTICAL POLICY PART
  - WORLD KNOWLEDGE PART
- The Tactical part uses the World Knowledge part as premises to enable its policy arguments
- The World Knowledge part helps understand the current state of the world.
  - The World Knowledge part is used to help recognize the current CONTEXT

Argumentation for Cognitive Assistants

- **TACTICAL POLICY**
  - R1: Normally, allow calls
  - R2: Busy with Important project then deny calls
  - C1: Family Emergency then allow calls despite work
    - **R1 >R2 when Family Emergency**

- **WORLD KNOWLEDGE**
  - The CEO has asked for the ARCO report today
    - HENCE we are in the Busy with important project Context
  - Baby not well today and wife is calling repeatedly
    - HENCE we are also in the Family Emergency Context.