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StructTactics.v

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(** https://github.com/uwplse/StructTact *)

Ltac subst_max :=
  repeat match goal with
  | [ H : ?X = _ |- _ ] => subst X
  | [ H : _ = ?X |- _ ] => subst X
  end.

Ltac inv H := inversion H; subst_max.
Ltac invc H := inv H; clear H.
Ltac invcs H := invc H; simpl in *.

Ltac break_if :=
  match goal with
  | [ |- context [ if ?X then _ else _ ] ] =>
    match type of X with
    | sumbool _ _ => destruct X
    | _ => destruct X eqn:?
    end
  | [ H : context [ if ?X then _ else _ ] |- _ ] =>
    match type of X with
    | sumbool _ _ => destruct X
    | _ => destruct X eqn:?
    end
  end.

Ltac break_match_hyp :=
  match goal with
  | [ H : context [ match ?X with _ => _ end ] |- _ ] =>
    match type of X with
    | sumbool _ _ => destruct X
    | _ => destruct X eqn:?
    end
  end.

Ltac break_match_goal :=
  match goal with
  | [ |- context [ match ?X with _ => _ end ] ] =>
    match type of X with
    | sumbool _ _ => destruct X
    | _ => destruct X eqn:?
    end
  end.

Ltac break_match := break_match_goal || break_match_hyp.

Ltac break_inner_match' t :=
  match t with
  | context[match ?X with _ => _ end] =>
    break_inner_match' X || destruct X eqn:?
  | _ => destruct t eqn:?
  end.

Ltac break_inner_match_goal :=
  match goal with
  | [ |- context[match ?X with _ => _ end] ] =>
    break_inner_match' X
  end.

Ltac break_inner_match_hyp :=
  match goal with
  | [ H : context[match ?X with _ => _ end] |- _ ] =>
    break_inner_match' X
  end.

Ltac break_inner_match := break_inner_match_goal || break_inner_match_hyp.

Ltac break_exists :=
  repeat match goal with

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  | [ H : exists (name : _), _ |- _ ] =>
    let x := fresh name in
    destruct H as [x]
  end.

Ltac break_exists_exists :=
  repeat match goal with
  | H:exists _, _ |- _ =>
    let x := fresh "x" in
    destruct H as [x]; exists x
  end.

Ltac break_and :=
  repeat match goal with
  | [ H : _ /\ _ |- _ ] => destruct H
  end.

Ltac break_and_goal :=
  repeat match goal with
  | [ |- _ /\ _ ] => split
  end.

Ltac solve_by_inversion' tac :=
  match goal with
  | [ H : _ |- _ ] => solve [inv H; tac]
  end.

Ltac solve_by_inversion := solve_by_inversion' auto.

Ltac apply_fun f H :=
  match type of H with
  | ?X = ?Y => assert (f X = f Y)
  end.

Ltac conclude H tac :=
  (let H' := fresh in
  match type of H with
  | ?P -> _ => assert P as H' by (tac)
  end; specialize (H H'); clear H').

Ltac concludes :=
  match goal with
  | [ H : ?P -> _ |- _ ] => conclude H auto
  end.

Ltac forward H :=
  let H' := fresh in
  match type of H with
  | ?P -> _ => assert P as H'
  end.

Ltac forwards :=
  match goal with
  | [ H : ?P -> _ |- _ ] => forward H
  end.

Ltac find_contradiction :=
  match goal with
  | [ H : ?X = _, H' : ?X = _ |- _ ] => rewrite H in H'; solve_by_inversion
  end.

Ltac find_rewrite :=
  match goal with
  | [ H : ?X _ _ _ = _, H' : ?X _ _ _ = _ |- _ ] => rewrite H in H'
  | [ H : ?X = _, H' : ?X = _ |- _ ] => rewrite H in H'
  | [ H : ?X = _, H' : context [ ?X ] |- _ ] => rewrite H in H'
  | [ H : ?X = _ |- context [ ?X ] ] => rewrite H
  end.

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Ltac find_erewrite :=
  match goal with
  | [ H : ?X _ _ _ _ = _ , H' : ?X _ _ _ _ = _ |- _ ] => erewrite H in H'
  | [ H : ?X = _ , H' : ?X = _ |- _ ] => erewrite H in H'
  | [ H : ?X = _ , H' : context [ ?X ] |- _ ] => erewrite H in H'
  | [ H : ?X = _ |- context [ ?X ] ] => erewrite H
  end.

Ltac find_rewrite_lem lem :=
  match goal with
  | [ H : _ |- _ ] =>
    rewrite lem in H; [idtac]
  end.

Ltac find_rewrite_lem_by lem t :=
  match goal with
  | [ H : _ |- _ ] =>
    rewrite lem in H by t
  end.

Ltac find_erewrite_lem lem :=
  match goal with
  | [ H : _ |- _ ] => erewrite lem in H by eauto
  end.

Ltac find_reverse_rewrite :=
  match goal with
  | [ H : _ = ?X _ _ _ _ , H' : ?X _ _ _ _ = _ |- _ ] => rewrite <- H in H'
  | [ H : _ = ?X, H' : context [ ?X ] |- _ ] => rewrite <- H in H'
  | [ H : _ = ?X |- context [ ?X ] ] => rewrite <- H
  end.

Ltac find_inversion :=
  match goal with
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => invc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => invc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => invc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => invc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => invc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => invc H
  end.

Ltac prove_eq :=
  match goal with
  | [ H : ?X ?x1 ?x2 ?x3 = ?X ?y1 ?y2 ?y3 |- _ ] =>
    assert (x1 = y1) by congruence;
    assert (x2 = y2) by congruence;
    assert (x3 = y3) by congruence;
    clear H
  | [ H : ?X ?x1 ?x2 = ?X ?y1 ?y2 |- _ ] =>
    assert (x1 = y1) by congruence;
    assert (x2 = y2) by congruence;
    clear H
  | [ H : ?X ?x1 = ?X ?y1 |- _ ] =>
    assert (x1 = y1) by congruence;
    clear H
  end.

Ltac tuple_inversion :=
  match goal with
  | [ H : ( _ , _ , _ ) = ( _ , _ , _ ) |- _ ] => invc H
  | [ H : ( _ , _ , _ ) = ( _ , _ , _ ) |- _ ] => invc H
  | [ H : ( _ , _ ) = ( _ , _ ) |- _ ] => invc H
  end.

Ltac f_apply H f :=
  match type of H with
  | ?X = ?Y =>
    assert (f X = f Y) by (rewrite H; auto)
  end.

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end.

Ltac break_let :=
  match goal with
  | [ H : context [ (let (_,_) := ?X in _) ] |- _ ] => destruct X eqn:?
  | [ |- context [ (let (_,_) := ?X in _) ] ] => destruct X eqn:?
  end.

Ltac break_or_hyp :=
  match goal with
  | [ H : _ \ / _ |- _ ] => invc H
  end.

Ltac copy_apply lem H :=
  let x := fresh in
  pose proof H as x;
  apply lem in x.

Ltac copy_eapply lem H :=
  let x := fresh in
  pose proof H as x;
  eapply lem in x.

Ltac conclude_using tac :=
  match goal with
  | [ H : ?P -> _ |- _ ] => conclude H tac
  end.

Ltac find_higher_order_rewrite :=
  match goal with
  | [ H : _ = _ |- _ ] => rewrite H in *
  | [ H : forall _ , _ = _ |- _ ] => rewrite H in *
  | [ H : forall _ _ , _ = _ |- _ ] => rewrite H in *
  end.

Ltac find_reverse_higher_order_rewrite :=
  match goal with
  | [ H : _ = _ |- _ ] => rewrite <- H in *
  | [ H : forall _ , _ = _ |- _ ] => rewrite <- H in *
  | [ H : forall _ _ , _ = _ |- _ ] => rewrite <- H in *
  end.

Ltac clean :=
  match goal with
  | [ H : ?X = ?X |- _ ] => clear H
  end.

Ltac find_apply_hyp_goal :=
  match goal with
  | [ H : _ |- _ ] => solve [apply H]
  end.

Ltac find_copy_apply_lem_hyp lem :=
  match goal with
  | [ H : _ |- _ ] => copy_apply lem H
  end.

Ltac find_apply_hyp_hyp :=
  match goal with
  | [ H : forall _ , _ -> _ ,
      H' : _ |- _ ] =>
    apply H in H'; [idtac]
  | [ H : _ -> _ , H' : _ |- _ ] =>
    apply H in H'; auto; [idtac]
  end.

Ltac find_copy_apply_hyp_hyp :=
  match goal with
  | [ H : forall _ , _ -> _ ,

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      H' : _ |- _ ] =>
      copy_apply H H'; [idtac]
    | [ H : _ -> _ , H' : _ |- _ ] =>
      copy_apply H H'; auto; [idtac]
  end.

Ltac find_apply_lem_hyp lem :=
  match goal with
  | [ H : _ |- _ ] => apply lem in H
  end.

Ltac find_eapply_lem_hyp lem :=
  match goal with
  | [ H : _ |- _ ] => eapply lem in H
  end.

Ltac insterU H :=
  match type of H with
  | forall _ : ?T, _ =>
    let x := fresh "x" in
    evar (x : T);
    let x' := (eval unfold x in x) in
    clear x; specialize (H x')
  end.

Ltac find_insterU :=
  match goal with
  | [ H : forall _, _ |- _ ] => insterU H
  end.

Ltac eapply_prop P :=
  match goal with
  | H : P _ |- _ =>
    eapply H
  end.

Ltac isVar t :=
  match goal with
  | v : _ |- _ =>
    match t with
    | v => idtac
    end
  end.

Ltac remGen t :=
  let x := fresh in
  let H := fresh in
  remember t as x eqn:H;
  generalize dependent H.

Ltac remGenIfNotVar t := first [isVar t | remGen t].

Ltac rememberNonVars H :=
  match type of H with
  | _ ?a ?b ?c ?d ?e ?f ?g ?h =>
    remGenIfNotVar a;
    remGenIfNotVar b;
    remGenIfNotVar c;
    remGenIfNotVar d;
    remGenIfNotVar e;
    remGenIfNotVar f;
    remGenIfNotVar g;
    remGenIfNotVar h
  | _ ?a ?b ?c ?d ?e ?f ?g =>
    remGenIfNotVar a;
    remGenIfNotVar b;
    remGenIfNotVar c;
    remGenIfNotVar d;
    remGenIfNotVar e;
  end.

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      remGenIfNotVar f;
      remGenIfNotVar g
    | _ ?a ?b ?c ?d ?e ?f =>
      remGenIfNotVar a;
      remGenIfNotVar b;
      remGenIfNotVar c;
      remGenIfNotVar d;
      remGenIfNotVar e;
      remGenIfNotVar f
    | _ ?a ?b ?c ?d ?e =>
      remGenIfNotVar a;
      remGenIfNotVar b;
      remGenIfNotVar c;
      remGenIfNotVar d;
      remGenIfNotVar e
    | _ ?a ?b ?c ?d =>
      remGenIfNotVar a;
      remGenIfNotVar b;
      remGenIfNotVar c;
      remGenIfNotVar d
    | _ ?a ?b ?c =>
      remGenIfNotVar a;
      remGenIfNotVar b;
      remGenIfNotVar c
    | _ ?a ?b =>
      remGenIfNotVar a;
      remGenIfNotVar b
    | _ ?a =>
      remGenIfNotVar a
  end.

Ltac generalizeEverythingElse H :=
  repeat match goal with
  | [ x : ?T |- _ ] =>
    first [
      match H with
      | x => fail 2
      end |
      match type of H with
      | context [x] => fail 2
      end |
      revert x]
  end.

Ltac prep_induction H :=
  rememberNonVars H;
  generalizeEverythingElse H.

Ltac econcludes :=
  match goal with
  | [ H : ?P -> _ |- _ ] => conclude H eauto
  end.

Ltac find_copy_eapply_lem_hyp lem :=
  match goal with
  | [ H : _ |- _ ] => copy_eapply lem H
  end.

Ltac apply_prop_hyp P Q :=
  match goal with
  | [ H : context [ P ], H' : context [ Q ] |- _ ] =>
    apply H in H'
  end.

Ltac eapply_prop_hyp P Q :=
  match goal with
  | [ H : context [ P ], H' : context [ Q ] |- _ ] =>
    eapply H in H'
  end.

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end.

Ltac copy_eapply_prop_hyp P Q :=
  match goal with
  | [ H : context [ P ], H' : context [ Q ] |- _ ] =>
    copy_eapply H H'
  end.

Ltac find_false :=
  match goal with
  | H : _ -> False |- _ => exfalse; apply H
  end.

Ltac injc H :=
  injection H; clear H; intros; subst_max.

Ltac find_injection :=
  match goal with
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => injc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => injc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => injc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => injc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => injc H
  | [ H : ?X _ _ _ _ _ = ?X _ _ _ _ _ |- _ ] => injc H
  end.

Ltac aggressive_rewrite_goal :=
  match goal with H : _ |- _ => rewrite H end.

Ltac break_exists_name x :=
  match goal with
  | [ H : exists _, _ |- _ ] => destruct H as [x H]
  end.

Tactic Notation "unify" uconstr(x) "with" uconstr(y) :=
  let Htmp := fresh "Htmp" in
  refine (let Htmp : False -> x := fun false : False =>
    match false return y with end
  in _);
  clear Htmp.

Tactic Notation "on" uconstr(x) "," tactic3(tac) :=
  match goal with
  | [ H : ?y |- _ ] =>
    unify x with y;
    tac H
  end.

(** generic forward reasoning *)

Tactic Notation "fwd" tactic3(tac) "as" ident(H) :=
  simple refine (let H : _ := _ in _);
  [ shelve
  | tac
  | clearbody H ].

Tactic Notation "fwd" tactic3(tac) :=
  let H := fresh "H" in
  fwd tac as H.

Ltac ee :=
  econstructor; eauto.

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